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THE MOSQUITOES OF THE LOWER FRASER VALLEY BRITISH COLUMBIA

BY ERIC HEARLE, B.S.A.

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THE MOSQUITOES

of

THE LOWER FRASER VALLEY, BRITISH COLUMBIA AND THEIR CONTROL.

By

ERIC HEARLE, B.S.A.

TABLE OF CONTENTS.

SECTION "A".

I. SUMMARY. 1

II. INTRODUCTION. - Mosquitoes in General. 2

(a) The Economic Importance of Mosquitoes 2
(b) Factors Concerned in the Abundance of Mosquitoes 2
(c) The Feasability of Mosquito Control 4
(d) Habits of Mosquitoes in General 6

III. THE FRASER VALLEY. 8

(a) Topography 8
(b) Industries and Development 9
(c) The Relation of Mosquitoes to the Industries of the Affected District. 10

(1) General 10
(2) Small Fruit Industry 11
(3) Live Stock & Dairy Industry 12
(4) Lumbering Industry 13
(5) Other Activities Affected 13

(d) Development of Public Interest In Mosquito Control 15

SECTION "B".

MOSQUITO FAUNAL SURVEY OF THE FRASER VALLEY: 18

I. SUMMARY. 18

II.(a) Mosquito Structure and Classification 19
Systematic Position 19
Characteristics of the Family 19
Structure of Adult Mosquitoes 20
Structure of Mosquito Larvae 21
Structure of Mosquito Pupae 22
Mosquito Eggs 22

II.(b) Keys to Fraser Valley Mosquitoes 23

Key to Genera - Adults. 23

Key to Species of Genus Culex - Adults 23
Key to Genus Culiseta - Adults 24
Species of Genus Mansonia - Adults 24
Key to Species of Aedes - Adults 24
Species of Genus Anopheles 26

Key to Genera - Larvae. 26

Key to Species Culex - Larvae 27
Larvae of Genus Culiseta 27
Larvae of Genus Mansonia 27
Key to Species of Aedes - Larvae 28
Larvae of Genus Ahopheles 29

III. DESCRIPTION AND ACCOUNT OF SPECIES IN HABITAT GROUPS. 29.

A. - FLOOD WATER MOSQUITOES. 30

(1) Flooded Meadows and Open Areas. 30

Aedes vexans Meigen 31

(2) Cottonwood Flood Swamps. 38

Aedes aldrichi Dyar 38
Aedes cinereus Meigen 46

B. - GENERAL BREEDERS. 47

Culex tarsalis Coquillett 48
Anopheles punctipennis Say 49
Anopheles maculipennis Meigen 50
Culiseta inornatus Williston 51
Culex testaceous van der Wulp 52
Aedes excrucians Walker 53

C. - RAINWATER BARRELS AND ARTIFICIAL RECEPTACLES. 54

Culiseta incidens Thompson 54
Culex pipiens Linnaeus 56

D. - FOREST AND MOUNTAIN MOSQUITOES. 57

Aedes punctor Kirby 58
Aedes aboriginis Dyar 59
Aedes lazarensis Felt & Young 60
Aedes canadensis Theobald 61
Aedes varipalpus Coquillett 62
Culiseta impatiens Walker 63
Aedes cataphylla Dyar 64
Aedes aloponotum Dyar 65

E. - GRASSY MARSHES. 66

Aedes flavescens Muller 66
Culiseta alaskaensis Ludlow 67

F. - PERMANENT SWAMPS CONTAINING MUCH VEGETATION. 67

Mansonia perturbans Walker 68

G. - SALT MARSHES AND COASTAL ROCK POOLS. 69

Aedes dorsalis Meigen 69

H. - ROCK BOUND RIVER CANYONS. 70

Aedes mutatus Dyar 71

List of Fraser Valley Mosquitoes arranged in Natural Order. 73

S E C T I O N "C".

THE CONTROL OF THE FRASER VALLEY MOSQUITO PEST. 75

1. GENERAL CONDITIONS:

(a) Factors Determining Mosquito Abundance - Comparison of Conditions 1919, 1920 and 1921. 75

(b) Extent and Nature of Breeding Areas. 77

Cottonwood Flood Swamps 78
Flooded Meadows and Open Lands 79
Ditches, etc. 80
Woodland and Mountain Breeding Places 80
Data Regarding Main Flood Water Breeding Areas. 80

II. NATURAL CONTROL FACTORS. 92

(a) Enemies and Other Natural Control Factors Affecting Mosquito Larvae. 92

Drying of Breeding Pools. 92
Insect Predators. 92
Water Mites. 93
Fish. 94
Shore Birds. 94
Salamanders. 94
The Value of the Enemies of Mosquito Larvae. 95

(b) Enemies and Other Natural Control Factors Affecting Mosquito Adults. 96

Freezing Temperatures. 96
Parasitic Worms. 96
Birds and Bats. 97
Parasitic Mites. 98

III. ARTIFICIAL CONTROL MEASURES. 98

(a) Permanent Control - Dyking and Pumping. 98

(b) Temporary Control Measures - Larvacides, Oils and Oiling Methods. 99

Canal Zone Larvacide. 101
Petroleum Oils and Oiling Methods. 101
Causes of Lethal Action of Oil. 101
Grades and Mixtures of Oils Recommended 102
Methods of Applying Oil. 104
Cost of Oiling. 105

(c) Protection from Bites of Mosquitoes. 105

Screening. 105
Repellants (For Humans) 106
Repellants (For Cattle) 107
Smudges and Fumigants. 109
Remedies for Bites. 110

(d) Conclusions and Recommendations. 110

References. 113

LIST OF ILLUSTRATIONS.

1. Diagram of Adult Female Mosquito.(after D.W. Lang.Brit.Mus.)
2. Diagram of Mosquito Larva (after D.W. Lang, Brit. Mus.)
3. Pupa of Mosquito (after D.W. Lang, Brit. Mus.)
4. Male genitalia - Photos by Ruhman and Hearle *
5. Eggs of Aedes. *
6. Aedes vexans Adult. Drawn by C.W. Young. *
7. Aedes vexans Larva, (after Howard, Dyar and Knab)
8. Typical Breeding Place of Aedes vexans. *
9. Floods on Sumas Prairie, breeding Aedes vexans. *
10. Sods Containing Eggs of Aedes vexans. *
11. Aedes vexans Adults emerging from flood pools. *
12. Aedes vexans Adults resting after emergence. *
13. Aedes aldrichi, Dyar, Adult Female. Drawn by C.W. Young.*
14. Larva of Aedes aldrichi, Drawn by C.W. Young. *
15. Cottonwood Flood Swamp. - Typical breeding place of Aedes aldrichi. (Photo by Duncan, Air Board, Vancouver). *
16. Near View of typical Aldrichi breeding place. *
17. Temperature conditions at flood season 1919 - 1921. *
18. Flood conditions. 1919 - 1921. *
19. Flood condistions during 3 worst recent years. *
20. Flood pools in Cottonwood swamp breeding Aedes aldrichi. *
21. Flood pools in open prairie breeding Aedes vexans. *
22. Semi-permanent pools breeding Culex tarsalis and Anopholes.*
23. Seepage filled railway ditch breeding Culex tarsalis, Aedes vexans and Anopholes. *

24. Permanent swamp area breeding Culex tarsalis and Anopholes.*

25. Permanent pool with cold deep water. No mosquito breeding.*

26. Typical habitat of Aedes mutatus (Fraser Canyon). *

27. Nicomen Island just prior to breaking of Dyke -1921.*

28. Flooded road at edge of Sumas Prairie. *

29. Sumas Prairie under flood. *

30. Chilliwack Valley under flood, 1894. Photo G.W. Edwards.

31. Mission during the great flood of 1894. Photo G.W. Edwards.

32. Floods near Hatzic 1894. Photo G.W. Edwards.

33. Small pumping station on Nicomen Island - 1921 flood. *

34. Air Board Seaplane at Hatzic Lake during Mosquito Survey. *

35. Aerial photo of part of Sumas Prairie. Photo by Duncan, Air Board. *

36. Aerial photo of E.end of Nicomen Island. Photo by Duncan, Air Board.*

37. Near view of 36 showing density of vegetation. Photo by Duncan, Air Board. *

38. Aerial photo of Floods at Fort Langley. Photo by Duncan, Air Board. *

39. Aerial photo part of Nicomen Island, 1921 flood. Photo by Duncan, Air Board. *

40. Nicomen Island, floods at 21' level. 12.VI.21. Aerial photos by Duncan, Air Board. *

41. " " " " " " " *

42. " " " " " " " *

43. Map of Main Flood Water Breeding Areas at 21' level. Compiled from Aerial photos and Observations. *

- * Original.

All photos by writer except where otherwise stated.

THE MOSQUITOES OF THE LOWER FRASER VALLEY, BRITISH COLUMBIA, AND THEIR CONTROL.

By

ERIC HEARLE, B.S.A.

Assistant Entomologist in Charge of Mosquito Investigations.

A. I. SUMMARY:

The abundance of mosquitoes in the Lower Fraser Valley, British Columbia, has forced itself upon the notice of all those who have settled there since the first white man ~~to~~ who penetrated into the district from the East left his record of the intensity of the pest. During seasons of bad outbreaks considerable losses have been ~~occassioned~~ caused to the lumbering, small fruit, dairying, and other industries that support the rural population. In the Spring of 1919 an investigation of the problem was commenced under the auspices of the Dominion Research Council and the Dominion Entomological Branch, and this project was continued by the latter Branch during 1920 and 1921. In the pages following are given the results of this investigation. All of the 24 species taken are briefly described and the two species constituting the pest are dealt with at some length. Ground surveys and aerial observations have resulted in the accumulation of much information regarding the breeding areas in the district and this is briefly given, together with weather records and charts showing the flood conditions during the period of investigation. The possibilities of mitigating the pest and the control methods adapted to the problem are also discussed - dyking and draining the huge flood water breeding areas are the most important steps in this connection, but oiling will also have to be resorted to.

II. INTRODUCTION - MOSQUITOES IN GENERAL:

(a) The Economic Importance of Mosquitoes.

In tropical countries mosquitoes assume such importance that they are rightly claimed to be the greatest insect enemies of mankind. Four diseases are transmitted solely by mosquitoes. Two of these - Malaria and Yellow Fever - are so terrible in the fatalities and the amount of suffering they have caused that they ~~outrival~~ exceed the late war in their destruction of human life.

In temperate and northern climates the aspect of disease transmission is one of monor importance; but in various localities mosquitoes occur in such enormous numbers that their attacks make life very unpleasant or even intolerable for man and beast; and where the districts contain important outdoor industries serious losses often result. In some areas the mosquito pest has been the chief factor responsible for retarded development of natural resources

(b) Factors Concerned in the Abundance of Mosquitoes.

The abundance of mosquitoes is regulated by a very complex series of factors. One of the most important of these is the topography of the country. Mountainous or hilly sections without level areas, are not so liable to be affected by serious mosquito outbreaks as are districts where there is much low-lying land. This is because the latter provide more facilities for the accumulation of shallow temporary collections of water suitable for mosquito development - as in the prairies of Saskatchewan and the salt marshes of New Jersey. Rainfall, the overflow from rivers and lakes, and tides are the factors which decide whether low areas will remain innocuous or will become the source of hordes of mosquitoes.

The extent of water in a district is not necessarily an accurate index as to the abundance of mosquitoes. Areas occur where numbers of lakes and permanent ponds and marshes are found, and yet mosquitoes are not troublesome. In most parts of British Columbia, little is to be feared from permanent bodies of water. It is where extensive temporary collections of water occur periodically that the most favourable conditions for the production of great swarms of mosquitoes are found. In nearly all permanent bodies of water the natural enemies of mosquitoes are well established and act as efficient checks by feeding on the larvae or wrigglers; whereas, in temporary collections of water, the quick breeding mosquitoes are able to develop unmolested before the predatory insects and fishes establish themselves.

Climatic factors are often of the greatest importance. Temperature largely determines the amount of food available and the rate of development of the larvae. A depression may be filled with water and a crop of wrigglers hatch out but because of continued low temperature and a corresponding slow growth, the mosquitoes may die before complete development is attained, owing to the early evaporation or draining away of the water.

The mode of life among the inhabitants often plays an important part in determining mosquito abundance in a district. Unsanitary conditions, and carelessness in storing and disposal of water provide breeding places for domestic and semi-domestic mosquitoes - the city of Panama(before the building of the Canal) and various ~~points~~ Parts of ~~to~~ the southern United States offer a good example of the above. In Eastern Canadian and American towns and rural villages, certain noxious domestic species breed in considerable numbers in rain water barrels, and in tin cans and other receptacles in garbage dumps, etc.

Fortunately in British Columbia the one mosquito breeding in any numbers in artificial receptacles is practically innocuous. (an introduced noxious domestic species (culex pipiens), has been taken but is very rare and has so far been found at one point only.)

(c) The Feasibility of Mosquito Control.

Many people still hold the conviction that mosquitoes cannot be effectively controlled, notwithstanding the fact that there are a number of excellent demonstrations of the feasibility of greatly mitigating the pests.

Successful mosquito control is dependent upon a thorough study of the particular species involved. Different species require different control measures. The habits, breeding places, range of flight and distribution are not identical in any two species; and these factors are of great importance in outlinging measures of control. In Panama, New Jersey, and other places where mosquito control on a large scale has been attempted, success was attained only after an exhaustive faunal study had been made.

In every district where mosquitoes are very abundant there are found to be certain key problems depending upon special conditions which favour the extensive development or one or more species of the mosquito fauna. In New Jersey attempts to alleviate the mosquito nuisance in towns and villages by local oiling proved ineffective in many cases and a study of the mosquitoes of the district revealed the fact that the species responsible for most of the trouble were salt marsh breeders which had migratory habits and which, at times, were found as far as forty miles from their breeding places. Flooding of the extensive salt marshes of the New Jersey coast at high tide, provided excellent conditions for the abundant development of three out of the forty species comprising New Jersey's mosquito fauna.

The importance of these three salt marsh breeders (Aedes sollicitans Wlk: Aedes taeniorhynchus Weid; and Aedes cantator Coq.) may be guaged from the following extract from the 1917 Report of the New Jersey Department of Conservation and Development. The Board states that "It is convinced that the salt marsh mosquitoes more than anything, or than all else, are responsible for the backwardness of the Eastern and Southern section of the State. They have depopulated farms, prevented the growth of towns, hampered the development of shore resorts, and restrained the development of suburban communities".(1) Conclusive demonstrations have proved that the mosquito pest of New Jersey can be controlled by the drainage of the salt marshes; or when complete drainage is not practicable, by ditching in such a way as to permit mosquito eating fishes to penetrate to all breeding places.

In the Panama Canal Zone conditions were very different. The troublesome species here were Aedes aegypti Lin; - the transmitter of Yellow fever - and several species of Anopheles responsible for the transmission of malaria. Aedes aegypti Lin.- a very domesticated species breeding chiefly in artificial receptacles - was favoured by the extremely unsanitary conditions obtaining in the native villages and towns. The Anopheles - breeding in any surface collections of water - were also abundantly provided for. The control of mosquitoes in Panama did not depend upon the drainage of huge marsh areas, so much as upon careful and frequent inspections in and around the cities and villages to ensure the observance of sanitary conditions and the proper disposal and storage of water. Filling of surface depressions holding water, the destruction of or screening of artificial receptacles in which mosquitoes might breed, and the use of oil and prepared larvicides proved effective measures in ridding the canal zone of its dangerous mosquitoes.

Such perfect mosquito control has been established that the Panama Commission of 1921 formed an opinion that a condition of super-sanitation had been reached in the city of Panama - as an index of this may be cited the fact that 45,000 members of the American Navy passed through Canal waters in that year without a single case of malaria being contracted. #(1)

(d) Habits of Mosquitoes in General.

Most people know something of mosquito habits, but it is surprising how many fallacies exist. The lust for blood, so strong in most mosquitoes in not universal and some species will not attack human beings. Some species affect cold-blooded vertebrates such as tree toads, many direct their attention mainly towards cattle and the larger wild mammals; while others are entirely vegetarian and subsist on nectar and plant juices. Blood does not appear to be essential to the life of even those species that evince the keenest desire for it, as these also feed on vegetation. In British Columbia the most bloodthirsty of mosquitoes may often be seen feeding on the nectar of Ocean spray (Spiraea discolor) and Yarrow (Achillea spp). It is probable, however, that a blood diet stimulates egg development. In all North American mosquitoes the males are entirely vegeterian; but in New Zealand a species has recently been taken in which the males can probe, and feed on blood. #(2)

The range of flight ~~in~~ of mosquitoes is very varied - some species remain strictly in the vicinity of their breeding places, while ~~others~~ one (Aedes Sollicitans) ~~have~~ has been known to migrate forty miles.

Some species are strictly nocturnal, others fly by both day and night. Most species show a preference for a certain specific time for their flights; in many this is shortly before and after sundown.

A fallacy that is very widely accepted is that an adult mosquito lives for a few days only. While it is almost impossible to obtain accurate information on this point under field conditions, there is no doubt that the span of life is much longer - probably about six weeks in most species. There is, of course, no truth in the supposition that a mosquito dies as soon as it has had a ~~feed~~ meal of blood.

The life cycle of a mosquito cannot be completed without water, ~~as~~ because the larvae and pupae are not adapted to any existence save an aquatic one. Mosquitoes cannot breed in damp grass.

Mosquitoes have four stages - the egg, the larva or wriggler, the pupa, and the adult. The eggs are laid in water or places in which water will collect. ~~They hatch~~ Out of the eggs emerge ~~into~~ the larvae which feed on organic matter such as particles of vegetation, micro-organisms, insect remains, etc., which occur in the water. These are ~~sucked~~ Driven into the gullet by means of mouth brushes; the constant movement of which draws a current of water, ~~and~~ with its contents, towards the larvae. The length of larval life is greatly dependent upon weather and food conditions and may vary from a few days to several weeks. There are four instars or larval stages.

The larva changes to the pupa, which lives in the water; is very active, but is unable to eat. The pupal period is usually much shorter than the larval one and terminates on the emergence of the adult. This is accomplished by means of a central split along the dorsum of the pupa, through which the mosquito draws itself and extricates its legs, wings and probosis from their cases in the pupal shell.

Drying is completed in a comparatively short time and the mosquito flies off to rest in the nearest shelter. While in warm climates biting may occur within a couple of days of emergence, observations indicate that in British Columbia mosquitoes seldom evince much desire for blood until nearly a week after emerging.

The male mosquitoes almost invariably emerge first and mating usually takes place very early in the life of the adult. In most species the male mosquitoes hover together in groups and dance up and down with erratic flight in the mating swarm. When a female approaches the vicinity of the swarm she is at once attracted to it and on entering is seized by a male. The pair drop out of the swarm and copulation takes place.

Doubtless many factors influence the rate of development of the eggs in the ovaries - and this appears to vary considerably in different species. In the writer's observation development in some species occupied over a month in the case of caged specimens.

The winter is passed by mosquitoes as the adult female in some genera; as the egg in others, and in a few species as the larva.

III. THE FRASER VALLEY.

(a) Topography.

The Fraser River hemmed in for many miles by the mountainous, rocky sides of the Fraser Canyon, emerges below Hope into the Fraser delta. From here to the Coast the river flows through a low lying valley of rich alluvial soil. Except for a few rib like projections such as the Chilliwack and Sumas mountains a great part of the valley is comprised of flat level land.

The low elevation may be gauged from the fact that Mission City, about forty miles from the Coast, has an altitude of only twenty-one feet above sea level. Winding through the valley to the river are many blind sloughs and small creeks. Here and there bordering these, and extending along the river, are a number of wooded areas, covered with Cottonwood, Willow, and a rank low growth of Spireaea, Wild Rose, and other vegetation. The river, which from September to May is usually a a at a very low level, at freshet time (from the end of May to early July) rises through the melting of the snows at its mountain sources. Water backs up the sloughs, and at times the low undyked cottonwood areas and open meadows become temporary swamps of very extensive dimensions.

(b) Industries and Development.

The Fraser Valley is the richest agricultural area in British Columbia. The deep alluvium found throughout the delta and the temperate climate assure excellent crops. These natural advantages have to a certain extent been offset by the main drawback to a large portion of the district - the prevalance of mosquitoes during the most important period for outdoor activities. During the last fifty years the valley has become fairly thickly settled - a great deal of the land taken up being devoted to mixed farming. In the various districts, different types of farming predominate. The dairy interests are very extensive at Chilliwack and large creameries have been established there. Dairying and cattle raising are also extensively followed in the Sumas and Abbotsford districts, around Dewdney, on Nicomen Island, Agassiz and other centres.

The Hatzic - Mission district is largely devoted to small fruit culture. The acreage under strawberries and raspberries especially, has increased with great rapidity during recent years and in 1920 amounted to over 1,000 acres in this section. The total acreage in small fruits in the valley was 2,520 acres in 1920.

The lumber industry of the valley is of vital importance and there are a number of mills and camps in the valley itself and in the adjacent country of higher elevation. The magnitude of the lumber operations may be understood from the fact that the largest lumber mills in the world are situated near the mouth of the Fraser river.

In the towns and villages throughout the affected area are a number of less important industries, such as brick and tile works, jam factories, etc.

(c) The Relation of Mosquitoes to the Industries of the Affected District.

(1) General.

It is almost impossible to obtain any very accurate estimates of the financial loss entailed when a district such as the Lower Fraser Valley is subjected to a serious mosquito outbreak. There can be no doubt however, that the mosquito pest is one of the most important adverse factors with which that district has to contend. The mosquito pest is felt by almost every industry in the affected area, and, although the pest is an intermittent one, the years in which mosquitoes appear in great intensity are sufficiently numerous to cause financial losses aggregating many thousands of dollars.

Below is given a table showing mosquito conditions since 1910, The table is compiled from data supplied by the Dominion Public Works Department, New Westminster, and from a comparison of the reports of a number of local residents. 1911 was one of the worst years in recent times and outside work was almost impossible. In 1911, 1913, 1916, 1918, and 1920 the pest was very general and a serious condition existed in the affected area of the valley.

Year	Height of Freshet.	Date of High Water.	Mosquito Conditions.
1910	15' 6"	June 15	No Pest.
1911	19' 1"	June 19	Very serious.
1912	15' 11"	June 26	No pest.
1913	18' 10"	June 16	Very serious.
1914	17' 2"	June 21	No pest.
1915	11' 6"	July 16	No pest.
1916	19' 3"	June 27	Serious.
1917	18' 5"	June 11	Moderate.
1918	20' 0"	June 23	Very serious.
1919	17' 4"	June 28	No pest.
1920	21' 0"	July 18	Very serious.
1921	21' 4"	June 12	No pest.

(2) The Small Fruit Industry.

The Mission - Hatzic district is one of the sections most affected by the mosquito pest, as it is here that small fruit culture - especially the growing of raspberries - is ~~one~~ most extensively carried on. At one time Oriental labour was mainly employed in this industry, but of late years nearly all the picking has been done by ~~white girls~~ young women from the cities, who consider berry-picking as a holiday and a change from urban conditions.

This class of labour is especially susceptible to the attacks of mosquitoes. Many of the girls exhibit considerable pluck in remaining at work, but their efficiency is very greatly reduced - picking berries and fighting mosquitoes certainly do not go well together and in some seasons a large number of girls are unable to stand the pest for more than a few days.

The main market for the Fraser Valley raspberry crop lies in the prairie cities, and for shipping long distances berries must be picked in the right stage of ripeness. This necessitates rapid picking which is found to be impossible when mosquitoes are troublesome. The mosquito season and the berry picking season coincide almost exactly/-At Chilliwack the first picking of raspberries was on July 4th in 1918; in 1919 on July 7th. The general emergence of the main crop of flood water mosquitoes usually occurs in the first week of July.

The loses incurred by small fruit growers through the mosquito pest are undoubtedly very great and according to Mr. Shook, leading grower in the Valley, amount to as much as 35 per cent of the crop during seasons of extreme mosquito abundance. In 1911 it is claimed that the loss of small fruit on Matsqui Prairie amounted to 75 % of the crop.

(3) The Live Stock and Dairy Industry.

Dairy and live stock farmers suffer much loss from the effects of mosquito attacks upon their stock. Enquiries were made among a number of dairy men and in every case it was stated that a marked reduction in the milk flow was noticeable in bad mosquito years. Those who gave a definite estimate placed this reduction at from 30 % to 40 % when mosquitoes were at their worst - and this even where protection was given by means of ~~with~~ smudges, etc.

There is a marked falling off in the condition of all cattle during a serious mosquito attack, and the suffering and loss among them may be guaged from the fact that cases have occurred where death has actually taken place as a result of mosquito attacks. Calves, foals, and in some cases, even mature animals have been among the victims. A number of poultry men stated that they had noticed a marked reduction in egg laying during seasons of mosquito abundance.

(4) The Lumbering Industry.

During the more serious mosquito outbreaks, the loss to one of the most vital industries of the Fraser valley - lumbering - has been very great. In 1911 practically all camps were completely closed down; and since then during years of mosquito abundance, logging undertakings have been greatly handicapped. Operations in the woods have frequently been suspended for as much as six weeks at a time.

(5) Other Activities affected by the Mosquito Pest.

As well as in the loss to the three very vital industries dealt with above, the mosquito pest is felt in many ways. A few of these are given below.

Brick Works.

At Clayburn, on the Matsqui Prairie, is a brick and tile factory employing about 150 labourers. Mr. Miller (Manager of the works from 1909 to 1916) stated that in 1911 (the worst year while he was in office), the attacks of mosquitoes caused the works to be completely closed down for three weeks, the workers leaving for Vancouver or other points outside of the mosquito zone. For six weeks the works were only

partly operated and for two months it was found impossible to work the mines at all. Had it not been for a large supply of raw material on hand it is probable that the works would have remained closed for several months.

Construction.

In 1911 an electrical plant for generating 40,000 horse power was under construction at Stave Falls near Ruskin. Mosquitoes appeared in intolerable numbers and it was feared that it would be impossible to hold the men at work although it was essential that construction be completed by a given date. The officers of the Company by guarantees that everything possible would be done to alleviate conditions, persuaded the men to remain. Over $2,000 were expended in mosquito netting, smudge material and other methods of protection. Every man was provided with a mosquito veil and guantlets; but the engineer in charge of construction stated, that even with the best protection that could be provided the efficiency of the labourers was greatly reduced. The men were even obliged to keep their veils on at meal times, and a continuous watch was kept night and day, to keep smudges burning in the bunk houses. The plant was successfully completed by January 1912.

The construction of roads and bridges and highways in the valley has been at times seriously retarded by the mosquito pest. Cases have come under the writer's notice of survey parties finding work almost impossible and the mosquito pest has been cited as being partly responsible for delays in the construction of certain important highways.

A very early reference to the hampering of public work is given by G.K. Lord, Naturalist to the B.N.A. Boundary Commission . In 1866 the International Boundary line was being cut in the Fraser Valley, and a camp of over 100 men was situated in the vicinity of Sumas Lake.

Mosquitoes became so abundant that the work had to be abandoned for several months and the men were obliged to retreat into the hills for refuge until the mosquitoes died off in the Fall. Lord gives a very graphic and interesting account of the intensity of the pest in his "Naturalist in Vancouver Island and B.C." Pps. 313-321.(4)

Agricultural Labour - Land Development, etc.

Other adverse effects of the pest are many and various. There is considerable difficulty in procuring and keeping agricultural labour in the worst portions of the affected area. Development of excellent land is retarded and cases have come before the writer's notice where returned soldiers intending to settle, have decided to locate outside the mosquito zone, as a result of a short experience of the pest.

Hotels and health resorts in the affected district suffer considerable financial losses during years of mosquito abundance. Visitors expecting to stay several weeks often leave within a day or two of arrival. Numbers of people - chiefly women and children - migrate from the affected zones during seasons of bad outbreaks. In 1911 there was a general exodus of the inhabitants of the small lumbering settlement of Steelhead, not far from Mission City. The mosquitoes which probably bred some six or seven miles away, settled in the shelter of the woods here and literally drove the people out.

(d) The Development of Public Interest in Mosquito Control.

Since 1808, when Fraser first penetrated to the delta of the Fraser fiver, we have records of the abundance of mosquitoes in this district. When his dug-outs emerged from the Fraser Canyon "The banks lowered to reedy swamps and mosquitoes appeared in clouds" (5).

The real agricultural settlement of the district has occurred within the last fifty years, and early settlers testify to the serious nature of the mosquito pest during pioneer days. It was no uncommon thing for many cattle - mainly calves - to be killed by mosquitoes during a single season. No idea of mosquito control was entertained, but most satisfactory measures for reducing the pest were employed, although without a realization of their significance in mosquito control. That is to say, as settlement became thicker, dyking was more and more resorted to, to prevent the annual flooding of large areas by the rise of the river. This dyking, and - to a certain extent the clearing of wooded land - is responsible for a reduction in the number of mosquitoes since the days of very early settlement. The district has of late years become of such importance that it would now seem necessary that haphazard control measures be augmented by more thorough and scientific efforts. Until recently very few people in the affected zone had any idea that mosquitoes were controllable, and the pest was suffered as a necessary evil. Like the tide and the weather, it was considered to be unalterable by any human interference. In the last few years a change has been indicated by the public agitations during and following bad mosquito seasons. The more enlightened residents of the affected area realize that it may be possible to alleviate conditions, and there is a very general desire that some action should be taken. Unfortunately owing to the intermittent nature of the pest, public agitation, which may be very intense during a bad season, fades away before it is brought to a point where definite action materializes.

The bad outbreak of 1918 resulted in the ~~passing~~ enacting of a Mosquito Control Bill early in 1919 by the Legislative Assembly of British Columbia. The form of the original bill that was drafted was so strenuously opposed by a number of the Reeves of affected districts in the valley that it was

never brought before the house. This bill was in many ways an excellent one and was along the lines recommended by the late Dr. C.G. Hewitt, ~~late~~ Dominion Entomologist. The bill that was substituted for it and that became law did not meet the needs of the Fraser Valley conditions, as it was based on an erroneous assumption that the species constituting the pest were non-migratory and would not wander far from the vicinity of the breeding areas. This act was therefore repealed in March 1921, and at present there is no legislation in British Columbia for the purpose of mosquito control.

Certain of the municipalities have for several years attempted to lessen the pest by local oiling operations. While these attempts are very commendable and may have some slight effect, it is the writer's opinion that until the larger areas are brought under control by dyking, individual municipal activities will never adequately cope with the situation, which should be handled as a whole under competent supervision.

It was found by the writer that a great number of people in the Lower Fraser Valley were unable to recognise mosquito larvae and lacked any clear idea of mosquito habits and life histories. In order to remedy this an educational campaign was undertaken by the Entomological Branch in 1919 and 1920. By means of newspaper and magazine articles, lantern lectures and exhibits at the various larger exhibitions and district fairs, numbers of very generally held popular delusions regarding mosquitoes and their habits were, to some extent, dispelled; and there is no doubt that since 1920 the inhabitants of the district have had a far less distorted idea of the nature of mosquitoes than that which formerly existed. It is futile to expect public backing in any entomological project until the people upon whom the burden of expenditure will rest are in possession of comprehensive information as to the nature and limitations of the measures needed, and the reasons for these measures. These data, are, we hope, to be found in sufficient detail in the following pages.

B. MOSQUITO FAUNAL SURVEY OF THE LOWER FRASER VALLEY.

I. SUMMARY.

The season of 1919 was almost entirely devoted to a survey of the mosquito fauna to ascertain what species occurred in the Lower Fraser valley and to obtain some idea of their relative abundance, distribution and importance. Prior to this time no systematic collecting of mosquitoes had been attempted in the valley, although one or two species had been taken by Dr. Fletcher and Dr. Dyar. Published records were restricted to a few notes of a very general nature, (Hadwen((6) a general memorandum (Cameron, Treherne & Hadwen) (7) and a reference to the taking of several species.- (Howard, Dyar and Knab) (8) The detailed survey that was now undertaken embraced the entire Fraser Delta and a small portion of the Fraser Canyon - an area of more than 2,000 square miles. The town of Yale was the easterly limit of the survey, which was extended westward to the coast. A number of trips were also made into the wooded mountainous area adjacent to the valley proper.

An automobile was used for this work, and trips of from one to four days were made radiating from headquarters. Larvae collected on these trips were placed in ½ pint sealers, a large number of which were carried in a special case at the back of the car. On return to the laboratory the material was tentatively worked over and placed in breeding jars; and adult specimens that had emerged from previous collections were examined and pinned. Collections of adult mosquitoes were also made throughout the territory and a close watch was kept on certain typical breeding areas, so that data as to life-histories under natural conditions might be available. A total of 24 species has been found in the district - but one of these appears to be introduced and not indigenous.

For a better understanding of the descriptions and remarks under the individual species, it has been thought advisable to include a brief summary dealing with the structure of mosquitoes, salient points used in classification and keys to the species found in the district.

II. (a) Mosquito Structures and Classifications.

Systematic Position. Mosquitoes belong to the order Diptera - that is insects in which the hind wings are replaced by halteres. Their position is in the sub-order Orthorrhapha - flies which emerge from the pupae by means of a T shaped opening on the dorsum of the thorax. They are included in the division Nematocera - flies with long many-jointed antennae.

Characteristics of the Family.

The family Culicidae, which comprises the mosquitoes, can be distinguished from others by the following characters. A diagnostic feature is the clothing of characteristic scales and hairs; the veins of the wings are well scaled and the venation is distinctive. The long proboscis, slender delicate appearance and complete marginal wing vein are characters that leave little chance of misidentification. Superficially there is some resemblance between mosquitoes and various members of the extensive family Chironomidae. Alive they can easily be distinguished when resting, as Chironomidae raise their front legs, whereas mosquitoes rest with their hind legs raised. Chironomidae have no long probosis and their wings are unscaled.

Structure of Adult Mosquitoes.: The scales clothing mosquitoes are of great importance as the markings and patterns formed by them are valuable specific characters in many cases.

The antennae are long and slender and consist of 15 segments. The palpi may be long in both sexes, or long in one and short in the other, or comparatively short in both. The proboscis is long, and in the females, adapted for sucking blood. Compound eyes only are present.

The thorax is broad and rounded, and the scutellum is large and may be either simple or trilobed. The wings are narrow and delicate and the veins are thickly clothed with scales - the shape of these and the venation of the wings are of some importance in classification. The legs are very long and slender and the markings and colouration on the femur, tibia and five tarsal segments frequently prove of value in classification. The tarsal claws are either simple or toothed and sometimes prove useful specific characters.

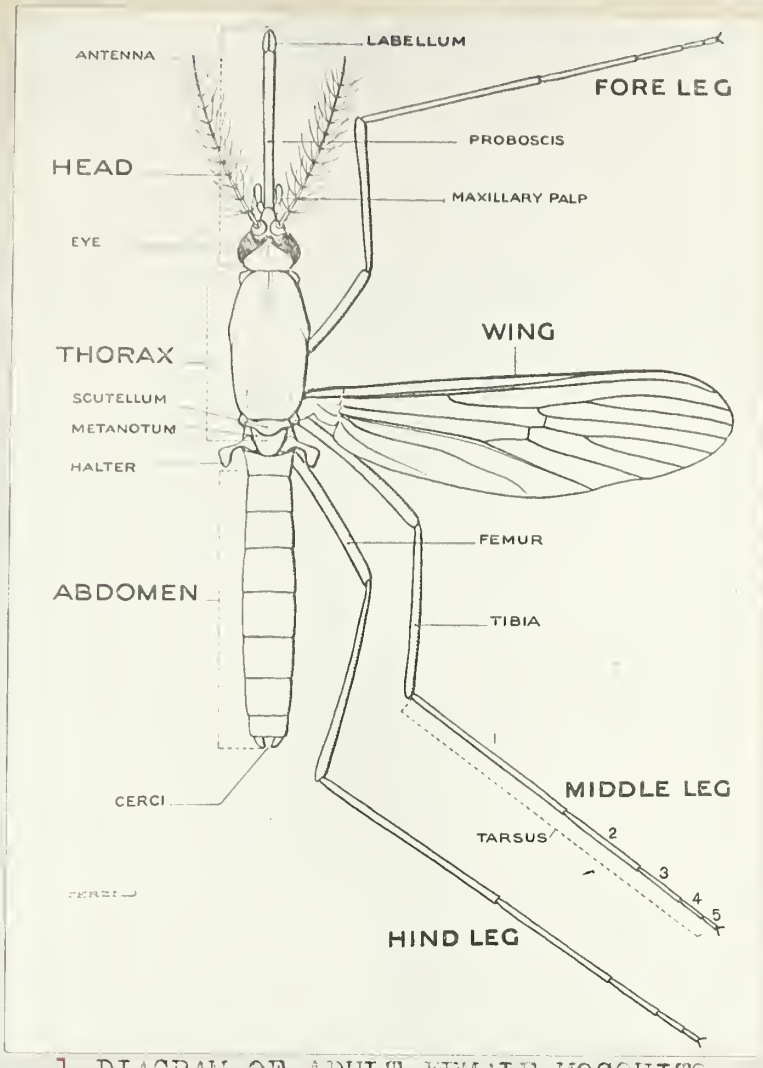
The abdomen is composed of 10 segments and is clothed with scales and hairs or hairs only. In the female the abdomen terminates in two cerci, prominent and exserted in some genera, but hardly visible in others. The large and prominent genitalia that terminate the male abdomen are of the utmost value in systematic studies and in the case of many species must be resorted to for accurate identification. In some groups the colouration of the females is so similar and so much variation occurs within specific limits that determinations are not always possible unless males are available. The proboscis of a mosquito is of the following structure. The piercing and sucking mouth parts are enclosed in a sheath formed by the labium. This is capable of being bent when the insect is sucking, so as to allow the head to come nearer the surface that is being probed. At the tip of the labium are two lobes, termed labella, which are covered with sensory hairs.

The sucking tube is formed by the labrum and hypopharynx; the two mandibles and two maxillae are long and piercing, the latter being saw-like at the tip. In the males the mandibles are lost and the maxillae are reduced (except in a single known species). (3).

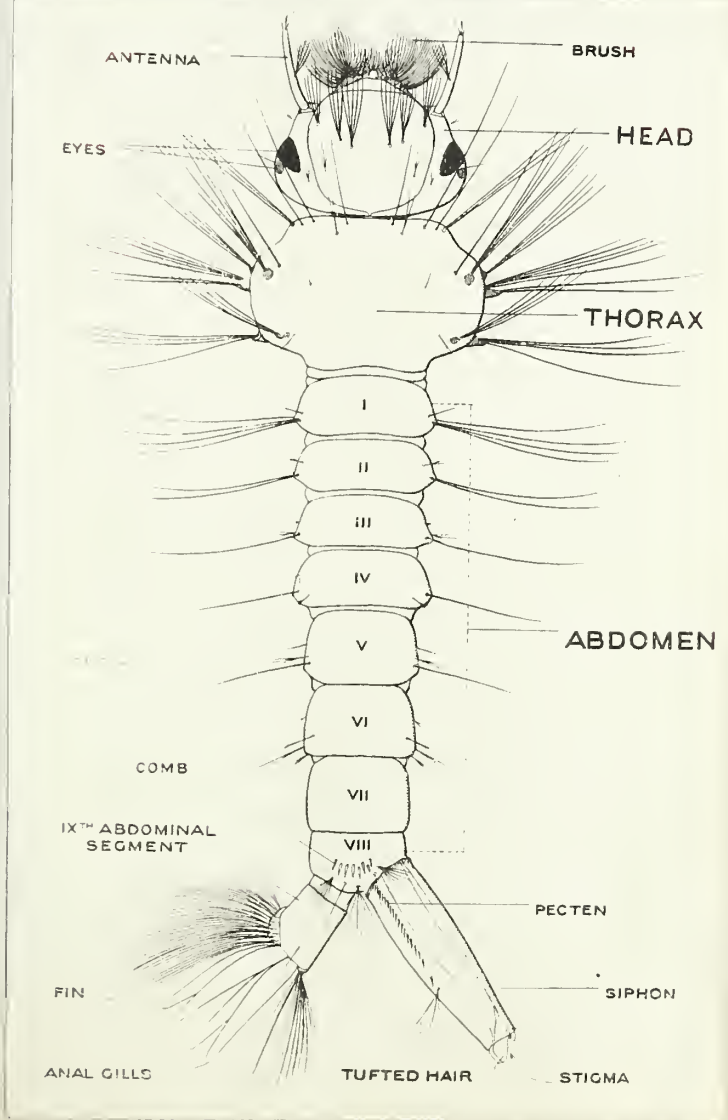
Structure of Mosquito Larvae.

A thorough knowledge of mosquito larvae is of as much, if not more, importance to those engaged in control operations as a knowledge of the adult insect. Mosquito larvae or wrigglers are elongated active organisms and are adapted to an aquatic existence only. They have a large rounded head, a broad thorax and an abdomen of 9 segments - the first 7 of which are very slightly differentiated from each other and which bear hairs usually comparatively few in numbers. The 8th and 9th segments are much modified and in all save the Anopheles are as follows:

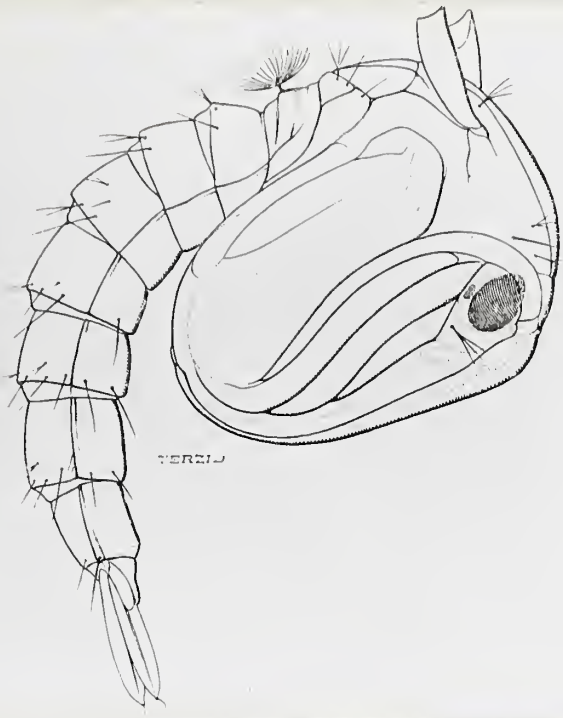
Projecting dorsally from the 8th segment is a tubular appendage- the anal siphon. This is usually supplied with two rows of short stout spines known collectively as the pecten. The anal siphon is used for obtaining air and is terminated by a small stellate valve which opens when the larvae is at the surface and closed upon submergance. On each side of the 8th segment is a patch of scales known as the lateral comb. These scales vary greatly in number, arrangement and appearance, and are of considerable value in classification. The 9th segment is not on the same plane as the preceding ones - it projects obliquely downwards. It is also considerably smaller than the others. Attached to it are four delicate organs-the tracheal gills, and ventrally there is an extensive tuft of hairs - the anal tuft.



1. DIAGRAM OF ADULT FEMALE MOSQUITO.
After D.W.Lang, Brit.Mus.

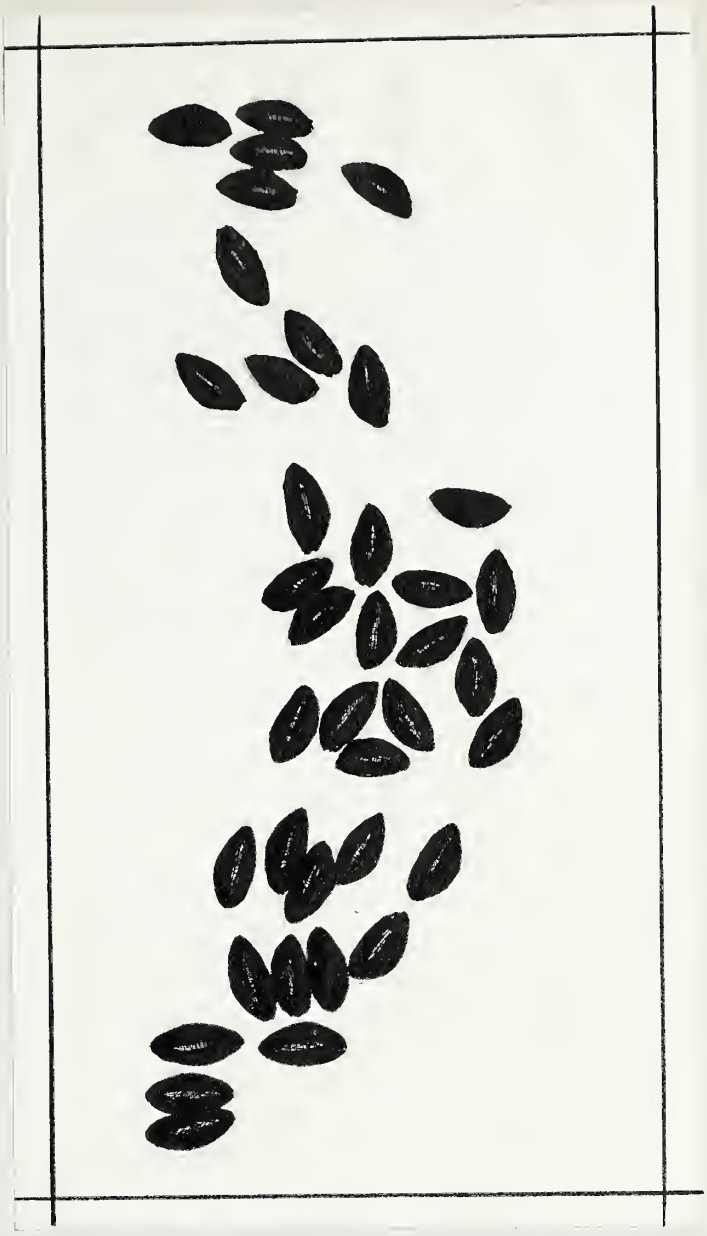


2. DIAGRAM OF MOSQUITO LARVA.
After D.W.Lang.



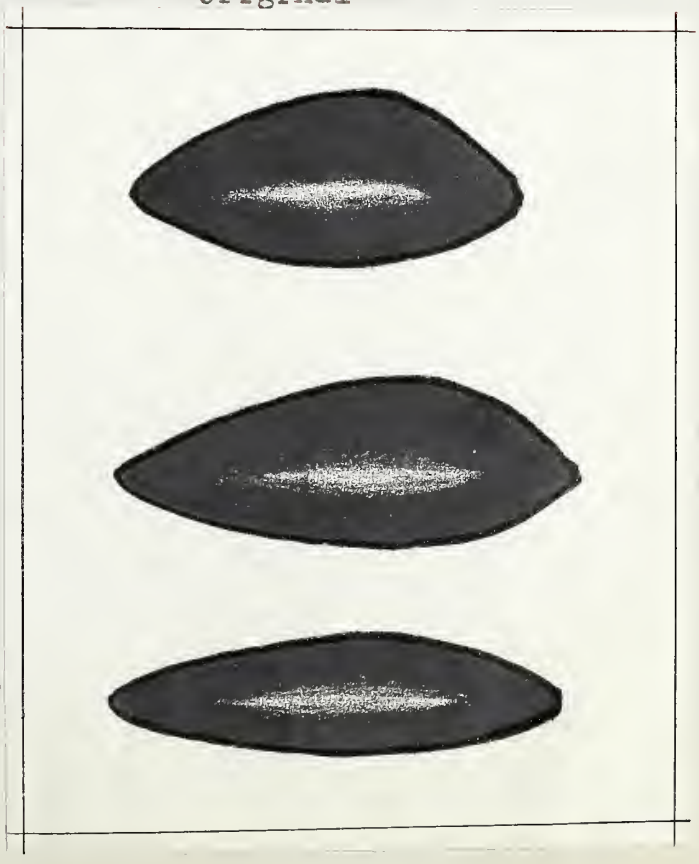
3. PUPA OF MOSQUITO (Aedes cinereus)
After D.W.Young, Brit.Mus.

4. MALE GENITALIA.
Photos by Ruhman And Hearle. (Original)



A BATCH OF ALDRICHI EGGS AS LAID ON WATER.

5. EGGS OF AEDES.
Original



Anopheline larvae differ from the Culicines as the respiratory anal siphon is replaced by a flat plate bearing two spiracles or stigmata. On the dorsal surface of the abdominal segments are stout stellate float hairs which enable anopheles larvae to rest horizontally at the water surface, whereas other mosquitoes float obliquely.

Structure of Mosquito Pupae.

The pupae of mosquitoes in general show less specific and generic differences that the other stages, and are little used in classification. They resemble a comma with a very large head. The thorax and head are fused together to form a compact rounded mass from which the 9 segmented abdomen curves downward and forward. The tip of the abdomen is provided with a pair of flat fins or paddles and the dorsal aspect of the thorax bears two breathing tubes. Culicine pupae rest in an upright position in the water and present a rounded appearance; a birds eye view shows the paddles projecting forward. The pupae of the anophelines rest more obliquely in the water and present a more ovoid appearance; the paddles in this case are completely hidden from above.

Mosquito Eggs.

The eggs of mosquitoes vary considerably in the various genera, and in the majority of cases appear to have specific differences, although our knowledge in this respect is very incomplete.

In the genus culex, Culiseta and Mansonia the eggs are laid together in rafts that float on the water surface. The individual eggs are cartridge shaped and are placed vertically in the raft with the pointed end uppermost. The eggs of raft making species are not always easily distinguishable.

The eggs of the genus Aedes are laid separately in loose clusters on the water surface and possibly also in damp low places without standing water. In the former case the eggs usually sink before hatching. The eggs are black and are ovoid or kidney shaped. They vary somewhat in size and appearance and it is often possible to identity them.

In the Anophelines the eggs are laid separately upon the surface as in the Aedes, but do not sink as they are supported by lateral membraneous floats. There are sufficient specific characters to render the different species distinguishable.

II B. Keys to Fraser Valley Mosquitoes. #1.

Key to Genera - Adults.

1. Scutellum rounded, not lobed - genus Anopheles Meigen
Scutellum distinctly trilobed 2.

2. Cross veins tending to lie in line, the posterior close to the anterior - Genus Culiseta Felt.
Cross veins normal, fairly widely separated. 3.

3. Abdomen of female pointed, Cerci exserted, hypopygium of male with side pieces prominently projecting, straight - genus Aedes Meigen
Abdomen of female blunt, with short inconspicuous cerci; hypopygium of male with side pieces curved downward or shortly projecting 4.

4. Wing scales, normal, narrow - genus Culex Linnaeus
Wing scales large and broad - genus Mansonia Blanchard

Key to Species of Genus Culex. Adults.

1. Tarsi white ringed at base and apex of segments; Proboscis ringed - Culex tarsalis Coquillett.
Tarsal segments and proboscis without bands 2.

2. White abdominal bands at base of segments; robust medium sized species - Culex pipiens Linnaeus

White abdominal bands at apex of segments ; small delicate species - Culex testaceus van der Wulp.

Key to genus Culiseta, Adults.

1. Tarsi ringed; wings spotted 2.

   Tarsi without white rings; wings unspotted 3.

2. Some of tarsal segments with very broad white rings - Culiseta alaskaensis Ludlow.

   Rings on tarsi very narrow; wings very heavily spotted - Culiseta incidens Thompson.

3. Many fairly broad pale scales near costal border of wings; No scales on cross veins - Culiseta inornatus Williston.

   Wings entirely dark scaled; cross veins usually with scales; colouration darker - Culiseta impatiens Walker.

Species of genus Mansonia.

One species only occurs in this district, and this is readily distinguishable by the characteristic very broad scales on the wings - Mansonia perturbans Walker.

Key to species of Aedes, adults.

1. Tarsal segments with white rings 2.

   Tarsal segments not ringed. 7.

2. Rings on base and apex of tarsal segments 3.

   Rings on tarsal segments at base only. 5.

3. Mesonotum without markings, uniform reddish brown - Aedes canadensis Theobald.

   Mesonotum with markings 4.

4. Black and white species; mesonotum with variable pattern of black and white; wing scales black. Aedes varipalpus Coquillett.

Brown and cream coloured species; Mesonotum with central and lateral brown stripe. Wing scales bi-coloured. Aedes dorsalis Meigen.

#1. In the preparation of these keys full use has been made of the keys in Howard, Dyar and Knab's Mos.N.& Cent. Amer., and Dyar's Mosquitoes of Canada. Trans. of Roy. Can.Inst. Toronto Vol.XIII, Part I, p.71. (9 & 10)

5. Tarsal rings very small, obdominal bands notched centrally; mesonotum uniform dusty brown - Aedes vexans Meigen.

Tarsal rings broad; abdominal rings not markedly constricted at centre. 6

6. Tarsal rings fairly broad, distinct; mesonotum dark chocolate brown centrally; grey at sides; abdominal bands sordid white. Small species (Aedes mutatus Dyar)
Large species (Aedes excrucians Walker)#2.

Tarsal rings very broad on hind legs, mesonotum uniform golden brown; abdominal bands cream coloured; abdomen more or less suffused with yellow scales.

Abdominal bands observed (Aedes flavescens Muller)
Abdominal bands usually concrete.
(Aedes aloponotum Dyar)

7. Abdomen with continuous white lateral line; Mesonotum uniform reddish brown; small delicate species.

Aedes cinereus Meigen.

Lateral white spots not joined to form continuous line; mesonotum not as above 8

8. Mesonotum clothed with light grey scales; if brown scales present these suffused and not forming distinct lines; a small robust species - Aedes cataphylla Dyar.

Mesonotum marked with distinct lines 9

9.Mesonotum typically with a broad median brown stripe #3 sides golden brown; medium sized species. Aedes punctor Kirby.

Mesonotum with a divided brown stripe ; yellowish grey at sides 10

#2. This may possibly be Aedes fitchii Felt & Young as adult females cannot be separated with certainty.

#3. Mesonotal colouring subject to much variation.

10. Mesonotum yellow, paired median lines narrow, and distinct, dark reddish brown; very small species - Aedes aldrichi Dyar & Knab.

Mesonotum yellow to grey - paired lines fairly narrow, black brown, less clean cut than above .
medium sized species - Aedes lazarensis Felt & Young.

Mesonotum yellow to brown - paired lines broad , dark brown, large species Aedes aboriginis Dyar.

Species of genus Anopheles;

Only two species of anopheles occur in the district and these are very readily distinguishable/.

Scales on wings dark except for coppery spot at apex on the fringe. - Anopheles maculipennis Meigen.

Wing scales yellow and black in large patches.
Anopheles punctipennis Say.

Key to genera - Larvae.

1. A sessile plate in place of air tube; stellate float tufts dorsally on some of abdominal segments; surface feeders - Genus Anopheles Meigen.

air tube elongate; no stellate float tufts on abdomen 2

2. Air tube without a pecten; outer half of air tube attenuated - Genus Mansonia Blanchard.

Air tube normal not markedly reduced or modified; well developed pecten. 3

3. Air tube with several pairs of ventral tufts.
Genus Culex Linnaeus

Air tube pecten produced into long hairs; hair tuft close to base - Genus Culiseta Felt.

Air tubes pectens of short scales or spines; hair tuft remote from base - Genus Aedes Meigen

Key to species of Culex Larvae.

1. Dorsal head hairs simple; breathing tube very long and thin; head large - Culex testaceus van der Wulp.
Dorsal head tuft multiple. 2

2. Lateral abdominal hairs in threes beyond second segment; colour usually green - Culex tarsalis Coquillett.
Lateral abdominal hairs in twos beyond second segment; sub-apical tuft on breathing tube lateral out of line with others; colour usually brown - Culex pipiens Linnaeus.

Larvae of genus Culiseta:

We have seen specimens and descriptions of three only of the four species occurring in the district; and these resemble each other very closely and have no very satisfactory characters upon which to base a key.

In Culiseta impatiens Walker both pairs of head tufts are multiple and alike, while in Culiseta incidens Thompson and Culiesta inornatus Williston the lower tuft has fewer hairs than the upper, and three of these are considerably longer than the others. The basal pecten teeth of Culiseta inornatus have more branches than those of Culiseta incidens.

Larvae of Genus Mansonia:

The peculiarly modified air tube of the larvae of Mansonia preclude the possibility of confusing the one species occurring in the district with the larvae of other ~~species~~ genera. The air tube in Mansonia perturbans Coquillett is only about twice as long as wide, is attenuated at the apical half, and is provided with hooks at the tips. The larvae attach themselves to roots of aquatic plants and do not come to the surface to breathe.

Key to the Species of Aedes larvae:

1. Anal gills very much enlarged, leaf like,

Aedes varipalpus Coquillett

Anal gills normal 2

2. Air tube with hair tufts within the pecten

Aedes cataphylla Dyar

Air tube with the hair tuft beyond the pecten 3

3. Pecten on air tube with detached teeth outwardly 4

Pecten teeth on air tube evenly spaced; no distinctly detached teeth. 6

4. Dorsal head tufts long and composed of many hairs; pecten with three detached teeth; lateral abdominal hairs single on segments three to six - Aedes cinereus Meigen

Dorsal head tufts comparatively short and composed of few hairs, four or under; pecten with two detached teeth. 5

5. Lateral comb with a few large scales (about 12) in an irregular double row; lateral hairs single on sixth abdominal segment; dorsal head tufts in twos and threes

Aedes vexans Meigen.

Lateral comb a triangular patch of about 25 fairly small scales; sixth abdominal segment with laterals double; dorsal head tuft in threes - Aedes flavescens Muller

6. Dorsal head tuft of five hairs or over

Aedes canadensis Theobald.

Dorsal head tuft of three hairs or under 7

7. Scales in comb numerous, about sixty; lateral abdominal hairs double to fifth segment, single on sixth; head hairs single - Aedes lazarensis Felt & Young.

Scales in comb fewer, seldom exceeding thirty. 8

8. Anal segment ringed by the plate; comb scales stout, thorn like in irregular row; six to seventeen.

Aedes punctor Kirby.

Anal segment with the ring broken inthe ventral line; comb scales, in a patch of 25 9

9. Head hairs triple in upper and lower tufts - Aedes aboriginis Dyar.

Head hairs usually single in lower tuft. 10

10. Pecten extending only slightly beyond basal third; head hairs triple in upper and single in lower tufts/ Aedes mutatus Dyar.

Pecten reaching middle of tube or nearly so; dorsal head hairs in twos or less. 11

11. Upper head tufts usually in twos, lower single; comb scales with strong central spine differentiated from others - Aedes aldrichi Dyar & Knab.

Head hairs single; comb scales usually without differentiated central spine - Aedes dorsalis Meigen

Larvae of genus of Anopheles:

While the larvae of Anophelines are among the easiest to distinguish from other genera, the two species occurring in the Lower Fraser valley are extremely difficult to separate. The only difference appears to be that in addition to five well developed float tufts common to both, Anophelie punctipennis Say has also a very minute tuft on the second segment.

III. DESCRIPTION AND ACCOUNT OF SPECIES - In Habitat Groups.

Most mosquitoes show a preference for breeding places of a more or less definite character. In some this preference is ~~loose~~ not very decided, but in most species it is fairly well defined. As the purposes of this bulletin are primarily of an economic nature, the various species dealt with have been grouped under their typical habitats, instead of being taken up in their systematic sequence. This arrangement is, of course, open to many objections, as a certain amount of over-lapping occurs, It is not intended however, that the grouping should be considered in an arbitrary or dogmatic manner - a certain amount of latitude must be allowed.

Of the twenty-~~three~~ four species taken in the survey five had not previously been recorded in British Columbia

and two were new to Canada. Only six species had previously been recorded as occurring in the territory embraced in the investigation/.

Although several species are fairly abundant in the district, only two-Aedes aldrichi Dyar & Knab and Aedes vexans-Meigen occur in sufficient numbers to constitute a serious pest. Their extreme abundance is determined by the vagaries of the river, which at times of high flood, overflows and provides conditions especially advantageous to them. In the wooded mountainous country adjacent to the valley Aedes punctor Kirby at times occure in great numbers in localized areas, but is of little economic importance. The larvae of Culiseta incidens Thompson occur in enormous numbers in almost every rainwater barrel, but the adults are practically innocuous, as this species only occasionally attacks man.

Culex testaceus van der Wulp, although common, is non-predaceous on man; and while a number of other species are vicious biters they seldom attain sufficient numbers to become important.

A. Flood Water Mosquitoes - The Main Problem.

There are two dominant species of mosquitoes in the Fraser Delta - Aedes aldrichis Dyar & Knab and Aedes vexans Meigen. The latter while occurring in great numbers, is of less importance than Aedes aldrichis, which is the main cause of the mosquito trouble in the Lower Fraser valley. Both species are favoured by the flood conditions in the valley at freshet time, but Aedes aldrichis is restricted to cottonwood flood swamps, while Aedes vexans finds conditions for maximum development in the more open areas.

(1) Flooded Meadows and Open Areas.

Extensive areas of open meadows and cleared land occur along the Fraser river. These, upon flooding, become ideal breeding places for Aedes vexans and it is in these temporary open swamps that this species finds the most satisfactory conditions for development, and is dominant.

Very few larvae of other species are found with it in large stretches of open flood water.

Aedes vexans Meigen #4.

Culex vexans Meigen, Syst. Reschr, Eur. Zweifl. Ins. VI, 241,1830

Recognition Marks.

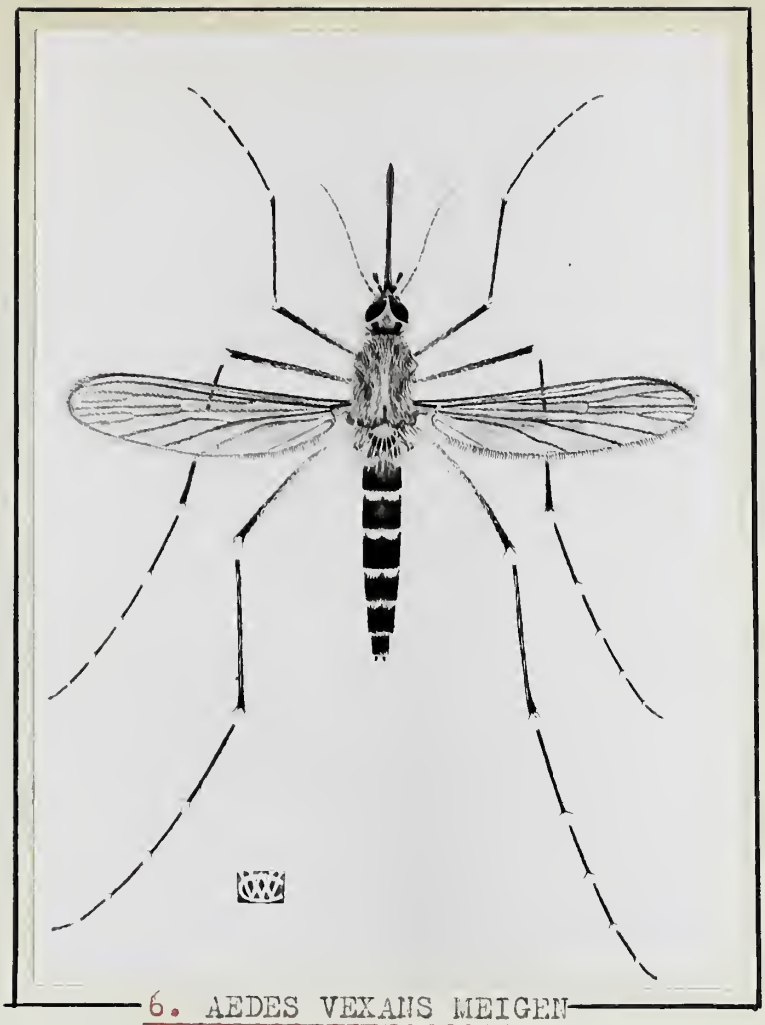
This is a small to moderate sized dusty brown mosquito, with legs very narrowly striped at the base of the tarsal segments. The main distinguishing character is in the abdominal banding; the segments of the abdomen have white narrow basal bands, which are so deeply constricted in the centre that they appear to be composed of two lunules. The proboscis is unbanded and brown and the thorax is uniformily clothed with dusty brown scales.

Importance.

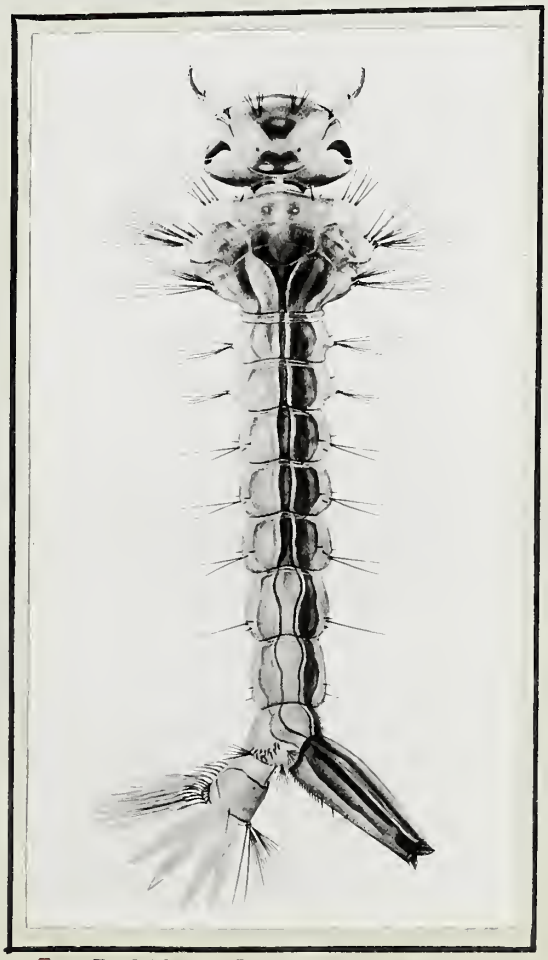
Aedes vexans is one of the two dominant mosquitoes in the Lower Fraser Valley and in bad seasons occurs in enormous numbers. During the three years embraced by the investigation we found it to be less important than Aedes aldrichii - numerically it was much outweighed and its poison is less virulent. It is however a very important factor in the ~~pest~~ outbreaks.

Distribution and Flight.

The species is distributed throughout the valley and specimens were taken between Yale and White Rock (on the coast). It occurs in greatest abundance however, between Agassiz and Fort Langley; although it is, at times, also very abundant near New Westminster and Port Mann. Aedes vexans is decidedly migratory and extends fairly freely in open country. There is no doubt that it can spread with ease to a distance of ten miles. In forested areas it does not seem to penetrate so far as Aedes aldrichi.



6. AEDES VEXANS MEIGEN
Drawing by C.W.Young.
(Original)

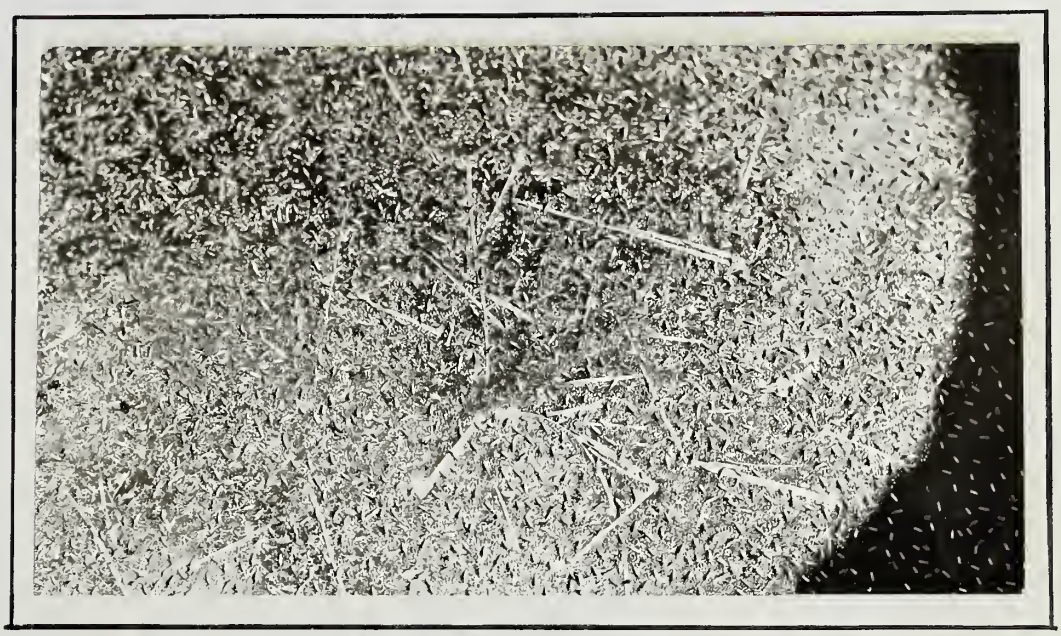


7. LARVA OF AEDES VEXANS.
After Howard, Dyar & Knab .

8. TYPICAL BREEDING PLACE OF AEDES VEXANS.
(Original)

9. FLOODS ON SUMAS PRAIRIE BREEDING AEDES VEXANS
(Original)

10. SODS CONTAINING EGGS OF AEDES VEXANS.
(See p 33 and Illustration No 8)
(Original)



11. AEDES VEXANS ADULTS EMERGING FROM FLOOD POOL.
(Original)

12. AEDES VEXANS ADULTS RESTING AFTER EMERGANCE.
(Original)

Breeding Places.

The main breeding places of Aedes vexans are in the flood pools of meadows and other places. The larvae are to be found to a lesser extent in temporary swamps protected by cottonwood and willow growth. Roadside ditches and general surface depressions filled with flood water usually ~~gave~~ yielded some larvae; but open flooded meadows are the characteristic habitat and it is here that Aedes vexans is dominant to the exclusion of almost all other larvae. Sumas Prairie when flooded produces incalculable numbers of this species.

Life History and Bionomics.

Overwintering of Eggs. The winter is passed in the egg stage - the eggs remaining unchanged in the flats and meadows until these are flooded. All the eggs do not hatch upon one flooding. The cold winter appears necessary before hatching can take place.

In July 1919 captive blood-fed females laid eggs on sterile sods covered with water. These sods were allowed to dry out and remained in the cages all winter. In May 1920 one of the dried out sods was submerged in warm water (100°f) and within an hour a great number of Aedes vexans larvae had hatched. Fresh sods cut at the same date from a depression in an open meadow gave large numbers of larvae upon being placed in warm water. In the late fall no larvae could be obtained from sods cut from the same place.

Effect of Temperature upon Rate of Hatching.

The temperature of flood water has some effect upon t the rate of hatching. Flooding sods at 101° F gave us larvae in as short time as one minute. With water at 50°F the larvae took several hours to hatch. A sod cut in half; one portion of which was flooded at 100°F and kept at 80°F, and the other flooded at 50°F and kept at this temperature; showed approximately the same number of larvae hatched.

after the lapse of twenty-four hours.

Eggs Do Not All Hatch at One Flooding.

Sods from the edge of a low-lying meadow were cut on June 1st, 1921, and samples were flooded on the same day with water at a temperature of 100° F. All re-flooding was at 100°. The sods were from thick grass clumps and were obtained within a few feet of each other. "A" was cut to approximately 3/4 foot square, while "B" was about 1/2 this ~~area~~ dimension. Both were treated identically throughout, the sods being allowed to dry out thoroughly after each flooding.

Flooded	Counts taken	No. Larvae "A"	No. Larvae "B"	Water Poured off.
June 1st, 10.00 am.	June 2nd, 3.00 pm.	1593	1553	June 2nd, 6.00 pm
June 7th 1.15 pm.	June 8th 1.15 pm.	1529	12	June 8th 2.30 pm
June 19th 12.30 pm.	June 20th 10.30 pm.	72	3	June 20th 2.30 pm
July 4th 12.30 pm.	July 5th 9.00 am.	24	0	July 5th 4.00 pm
July 15th 12.05 pm.	July 17th 12.05 pm.	0	0	Experiment terminated.
	Total -	3218	1568	

A meadow sod left dry in the laboratory since July 1919, was flooded with warm water on May 7th, 1920 and a large number of Aedes vexans larvae emerged. The water was permitted to remain. On June 4th minute freshly hatched larvae were noticed among the fully grown ones hatched on May 7th. No egg laying could have taken place in the dish as this was screened; and a marked increase in temperature was evidently responsible for this fresh hatching. The average maximum temperature for the period between May 8th and June 2nd was 67° F. Up to May 31st, 70° F. was the highest temperature reached. In the first three days of June, however, there was a sudden rise in temperature - on June 2nd the temperature rose to 80° F

and on the third to 84° F.

Development of Larvae and Pupae:

Temperature is an important factor in the rate of development of the immature stages. In 1919 there were two distinct floodings of a typical meadow breeding place. The first was on May 7th and the larvae hatched on this date developed fairly slowly; the adults emerged in five weeks. The second flooding and hatching occurred about June 25th and the adults emerged within 19 days. In 1920 the earliest larvae hatched at the same place on June 9th developed to adults within two weeks. In 1921 development of the earliest larvae took from three to four weeks.

Under laboratory conditions larvae hatched on May 7th, 1920, pupated during the last week in May and adults emerged on June 3rd, 5th, 7th and 13th. Larvae hatched on August 16th, 1920, pupated in 10 days, the earliest adults emerging six days later.

Experiment to Illustrate the Retarding Effect of Cold upon Larval Development.

A sod from the edge of a meadow was cut into half and each portion was placed in a pan and flooded. "A" was flooded at 50°F and kept at approximately this temperature (never exceeding 54°F). In seven days the larvae had only doubled their original size. "B" was flooded at 100°F and kept at a temperature of ~~pap~~ approximately 80°F. In seven days the larvae were about 3/4 grown. The experiment concluded here through an accident to one of the dishes.

Time Elapsing after Emergence Prior to Biting:

A pailful of Aedes vexans pupae was taken from a flooded meadow on June 30th and was placed inside a cheesecloth tent ~~inside~~ the laboratory. Numbers of adults had emerged before night. They showed no desire to ~~probe~~ bite on the first day although both sexes fed avidly on bananas within an hour of emergence.

On July 2nd very few even attempted to probe although the tent contained many thousands. By July 5th, however, a keen blood lust had developed and on this date the females attacked viciously as soon as the tent was entered. All tests were made just after dusk and the sleeves were rolled up to provide a good surface for probing.

Plant food in Nature: The blossoms of white spiraea are often found covered with males and females of this species which appear especially fond of the nectar.

Mating: The males shortly after emergence swarm in considerable numbers at dusk. They often swarm in meadows and fields, but may also hover in open places in woods. The females approaching singly are seized on entering the swarm, and copulation takes place.

Attraction to Light: Aedes vexans seems much more drawn to lights than any other species we know - the males being so especially susceptible that this acts as a very good index to the emergence of new batches.

Egg-laying: Dissections made in 1922 gave an average of 132 eggs in the ovaries. The maximum number found was 182 and the minimum was 108. The eggs were evenly developed. To minimize error only those specimens were taken into consideration in which the eggs were from 1/2 to 3/4 developed.

Specimens were taken with fully developed ovaries in the first week of July (in 1921.) Egg-laying continued from this time on to the end of August; the period between July 15th and 22nd showing the greatest activity in oviposition. In 1919 a large proportion of this species taken by sweeping in the third week of July showed fully developed ovaries, and several specimens oviposited in the cages on July 22nd. Oviposition was observed in one case - the eggs were ejected very rapidly, often following each other with only a few seconds interval.

On being laid the eggs were pearly white but gradually attained a bluish tinge, which darkened until in 3/4 of an hour the colour was a deep blue black. All the eggs were laid in one batch and a dissection showed no sign of further development of the ovaries *5. The eggs rested on the water surface singly and in irregular clusters. They did not sink for some days.

*5. NOTE:

> Although there can be no doubt that Aedes vexans almost invariably lays but a single batch of eggs, our dissections brought to light one specimen that indicated that exceptions to the rule might exist. The specimen was taken in woods on July 22, 1921, by sweeping. The ovaries contained 145 eggs and these were all in the same stage of development - about 1/4 developed. Besides these in the tip of the abdomen was a single fully developed egg, jet black in colour.

Effect of Parasitism upon Egg-laying:

A fairly large percentage of Aedes vexans adults examined were found to contain a nematode parasite - Parameris Canadensis Steiner (11). This was the only species at all seriously affected - some samples examined showing 80 % parasitism. The presence of nematods appears to prevent egg development and the parasite must be a very important factor in keeping down the numbers of Aedes vexans.

Description of Egg:

The egg is irregularly fusiform and tapers rather sharply towards one end. The tapering towards the end on which the micropyle is situated is less acute. The colour is jet black and the reticulations are small and in irregular rows.

Selection of Site for Deposition of Eggs:

That some selection is exercised in choosing the place for depositing the eggs is indicated by the following . Sods cut from thick matted clumps of grass from a depression at the edge of an open meadow, gave enormous numbers of larvae upon submergence in warm water. Loose ~~dirt~~ Soil and debris from between

the clumps of grass gave no larvae at all.

Counts were made of larvae from sod, ~~dirt~~ (some soil), etc. taken from an open meadow-like depression at the edge of a cottonwood swamp. The same area of sod, ~~etc.~~, was used in each case (about 1 square foot) and each sample was flooded with water at 90°F.

Sods mostly grass.	86 larvae.
Sods, mossy.	65 larvae.
Loose ~~dirt~~ (soil), dead leaves, twigs.	35 larvae.
Moss from fallen logs.	0 larvae.

Summary of Life History:

The winter is passed in the egg stage in low meadows and other open places subject to flood. Upon a single flooding only a certain proportion hatch, ~~it~~ sometimes ~~taking~~ as many as four floodings are necessary to hatch all the eggs. A sudden rise in temperature may not act in a similar manner to drying and reflooding. A hibernating period throughout the winter appears necessary before the eggs can hatch. The rate of larval development depends upon temperature, under natural conditions it may take from two to four weeks for the adult stage to be reached. Mating occurs early in the life of the adults. There is no blood lust for the first four or five days although fruit juices and nectar are acceptable within a few hours after emergence. The blossoms of white apirea are very attractive to both sexes, but more especially to the males. This species is much more attracted to lights than any other in the district. Egg laying takes place about three weeks after the females have emerged, about 130 eggs being laid - usually in a single batch, The eggs, which are fusiform and jet black, are laid singly in loose clusters, and preference is shown to thick clumps of grass as sites for oviposition. The normal span of adult life is about six weeks.

(2) Cottonwood Flood Swamps:

The flooded bottom lands of the Fraser of the greatest importance are those clothed with dense vegetation; cottonwood, willow, spireae, rose, etc., - as the larval habitat of Aedes aldrichi Dyar is almost restricted to these cottonwood swamps .* (12). This is the typical breeding place of Aedes cinereus Meigen, and Aedes wexans larvae also occur in numbers, although they are more strictly habitate of open areas. Aedes lazarensis larvae also may be found here but are very rare.

Aedes aldrichi Dyar & Knab: * 6.

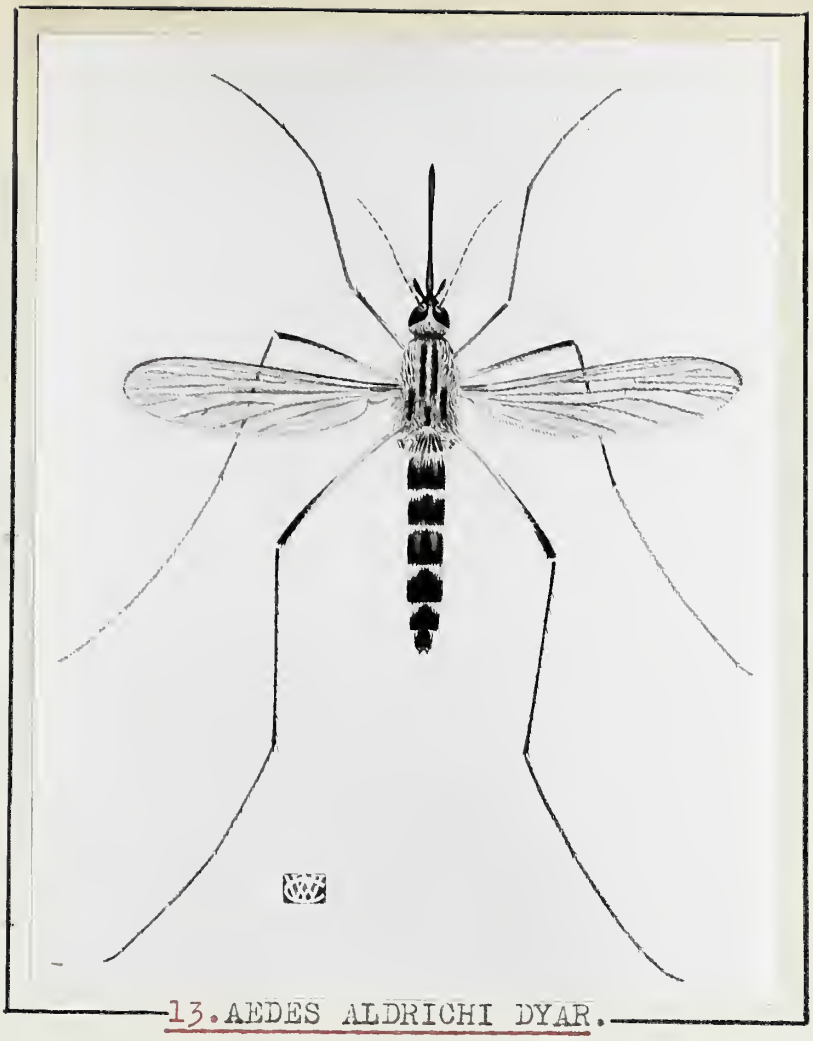
Aedes aldrichi Dyar & Knab, Proc. U.S.Nat.Mus.XXXV,57, 1908.

Recognition Marks:

This small grayish mosquito has fairly distinctive markings. The mesonotum is clothed with yellowish grey to straw-coloured scales, and is ornamented with a well defined median divided line of dark brown scales, and two short lateral posterior stripes of the same colour. The abdomen is black with crisp white basal bands, which broaden laterally on the posterior segments to form white triangular patches. The legs and proboscis are browmish black and unbanded, and the wings are delicate and wholly dark scaled.

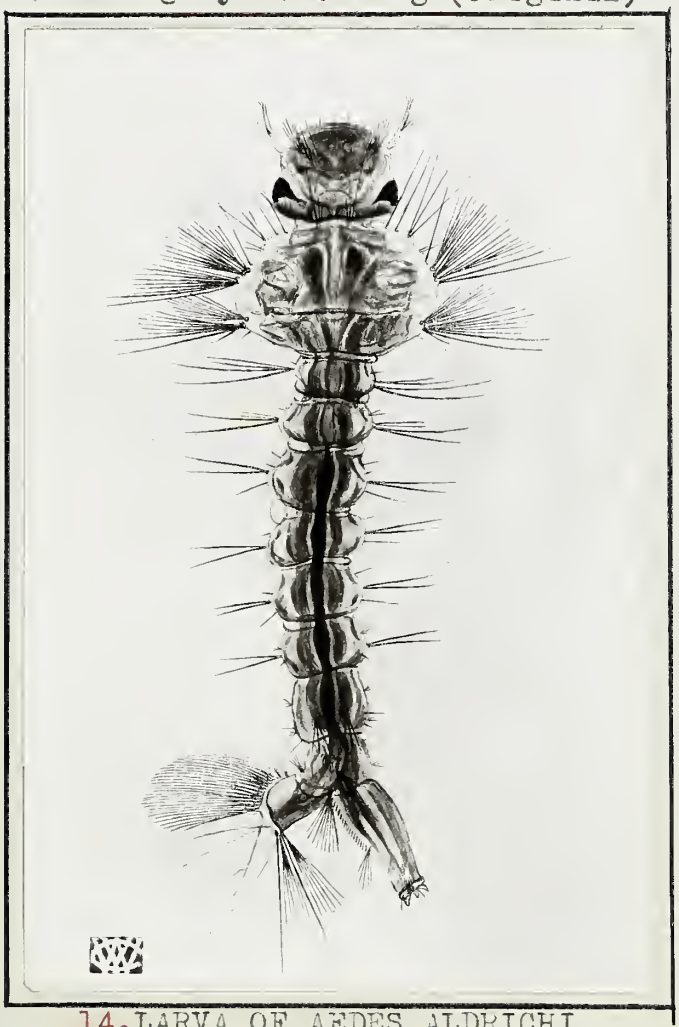
Importance: This is the most important species in the Lower Fraser valley, and during the period of our investigation proved to be more abundant than all the other 24 species combined.

*6. Hatzic, B.C. June 15, 1919(E. Hearle)



13. AEDES ALDRICHI DYAR.

Drawing by C.W.Young (Original)



14. LARVA OF AEDES ALDRICHI

Drawing by C.W.Young (Original)

15. COTTON-WOOD FLOOD SWAMP,
Typical Breeding Place of Aedes aldrichi
Aerial Photo by Duncan, Vancouver.
(Original)

16. NEAR VIEW OF TYPICAL ALDRICHI BREEDING PLACE.
(Original)

The writer collected the mosquitoes that settled on his arm during a period of a few minutes in an open place near Hatzic Lake at 9.30 p.m. on July 2nd, 1919, with the following results:- Aedes aldrichi 34; Aedes vexans 4; Aedes cinereus 2; Culex tarsalis 2. Anopheles maculipennis 2; Mansonia perturbans 1. In many parts of the district the numerical superiority of aldrichi would be as marked as the above but Aedes vexans often equalled it in nmubers.

Aedes aldrichi is a very vicious biter and the effect of its probing is very painful. It shows great persistence in invading houses and its small size often permits penetration through the ordinary screens. Although it is generally most troublesome towards dusk it will bite throughout the day, especially where berry canes and woods afford protection. It is most abundant in sheltered places, but, during seasons when the conditions are satisfactory is troublesome in the open as well.

Distribution: Although the larval habitats are restricted to Cottonwood bottom lands bordering the river, our collections showed adults from Yale to the Coast (White Rock) and for a number of miles into the wooded mountainous area adjacent to the Valley proper. The area where they proved to be most abundant lies between Ruskin and Hope. During some seasons when conditions are adverse they remain strictly in the vicinity of their breeding places, but in most years when they develop in great numbers they permeate the entire surrounding district - sheltered wooded areas being especially suited to their spread.

Migration Data: While we conducted no detailed experiments regarding migration, we have good evidence that Aedes aldrichi may migrate 15 miles; and that during years of great abundance a general infestation as far as ten miles from the breeding area is by no means uncommon.

Our data dealt mainly with the heavily timbered mountainous area north of the river, and the cover and protection provided doubtless facilitate extensive movement. In the more open areas it has been our experience that only especially favourable conditions will entice appreciable numbers into the open any great distance from the protection of woods, raspberry plantations and other cover.

Larval surveys in the back country north of the river bottom lands indicated unsatisfactory conditions for the development of either Aedes aldrichi or Aedes vexans . Aedes punctor develops very extensively in the snow pools in some restricted places - especially high in the mountains but we were unable to find any larvae, or suitable habitat for larvae, of either Aedes aldrichi or vexans.

Within a few days of the general emergence of the flood water mosquitoes in the bottom lands, surveys were made as far as fifteen miles to the north and no specimens of the two species were taken - they were at this time teeming in the cottonwood flood swamps adjacent to the river. To give two specific examples :-

On June 30th, 1920, the general emergence of Aedes aldrichi and Aedes vexans occurred from the majority of the river flood pools in the vicinity of Mission and Silverdale. All the sheltered areas immediately adjacent were teeming with these two species. On the same date a survey for adults at Steelhead six miles north gave no specimens at all. On July 6th warm moist breezes blew north from Mission and within three days reports were received from lumbermen that small brown mosquitoes were appearing in numbers. Later in the season the entire Steelhead district was permeated with mosquitoes (largely Aedes aldrichi and less Aedes vexans.) and lumbering operations were much hampered.

In the season of 1921 mosquitoes (Aldrichi and vexans) were abundant only in the immediate vicinity of the flood pools and there was practically no migration. Emergence at the various river breeding areas took place from June 6th to June 23rd. Surveys at Steelhead on June 19th and July 5th revealed neither larvae or adults of either Aldrichi or vexans.

The McConnell Creek area ~~lies~~ Lies some 12 miles north of the Fraser river and is devoted almost entirely to lumbering. In 1921 (when little migration occurred) a survey for adult mosquitoes gave very little save Aedes punctor - none of the flood pool mosquitoes were taken, with the exception of a single specimen of Aedes cinereus. On July 9th another survey was made and mosquitoes were found to be extremely scarce; only one or two Aedes aldrichi and Aedes vexans were taken, while on this date the two species were very abundant in the river bottom lands in which they bred.

In 1920 conditions were very different as extensive migrations occurred. The first survey for adult mosquitoes in the McConnell Creek area was made on July 2nd (within 3 or 4 days of the general emergence in the river flood pools). At this date Aedes punctor was the only Aedes on the wing. On July 18th a trip was made to the top of McConnell mountain. At the summit (about 3,000 feet) Aedes punctor freshly emerged from snow pools, occurred in enormous numbers, but gradually decreased as lower levels were reached. At about 1,000 feet the first of the Aedes aldrichi were encountered. At the base of the mountain they were slightly more numerous and a single Aedes vexans was also taken. At a mile and a half further south Aedes aldrichi were still more numerous, and local residents informed us that they had appeared within the last two or three days. Collections at

intervals of several miles along the road south to the river gave increasing numbers as the flooded areas were approached. Most of the specimens were Aedes aldrichi and Aedes vexans was much less abundant. In the immediate vicinity of the cottonwood flood swamps Aedes aldrichi occurred in vast numbers and were many times more numerous than Aedes vexans. By July 27th the McConnell Creek area had become so permeated with mosquitoes t that all lumbering operations ceased and camps and mills closed down. The mosquitoes causing this were not the local-bred Aedes punctor which was only very abundant in restricted areas at a high elevation; but Aedes aldrichi which bred in the river flood pools and gradually migrated ~~back~~ north. The migration extended over a period of two or three weeks. A survey on August 19th gave very few Aedes punctor compared with large numbers of Aedes aldrichi . Aedes vexans were comparatively scarce.

Breeding Places: Typical cottonwood flood swamps are almost exclusively the breeding place of Aedes aldrichi Extensive larval surveys in every type of larval environment indicated that this species has decided habitat preferences, and larval counts showed it to be about 80 % dominant in its chosen habitats *7. At Silverdale counts were made from a flooded area, one half of which was undeveloped cottonwood swamp, while the other half had been cleared and converted into an open meadow. Larval counts from the cleared areas were as follows. 11 Aedes aldrichi to 216 Aedes vexans. Within fifty yards a flood pool in the unreclaimed cottonwood portion gave the following count - Aedes aldrichi 121, Aedes vexans 44, and Aedes cinereus 4. Occasionally aldrichi larvae were met with in open Roadside depressions at the edge of cottonwood flood swamps, but this was rare.

* 7 See also list under breeding areas. P.80

The breeding places to which they were almost exclusively restricted were the low river bottom-lands covered with a jungle-like vegetation of cottonwood, willow, spiraea, etc.

Life History and Bionomics:

Development and Habits: As in other Aedes, the winter is passed in the egg stage, the eggs lying in the depressions of the cottonwood bottom-lands until awakened to active life at the flooding of the breeding places by the freshet waters. The life history is very similar to that of Aedes vexans. Larvae usually hatch immediately upon the submergence of the eggs and develop in the water for a lesser or greater period depending upon temperature, etc. In 1919 development from egg to adult was complete in approximately three weeks. In 1920 this period was considerably less and the adult stage was reached in about two weeks. In 1921 over three weeks were needed for development. The pupal stage is of comparatively few days. Adults apparently do not evince a strong blood lust for several days after emergence. Both species feed on nectar and plant juices and are especially attracted to the flowers of white spireae. Horses and cattle as well as humans are attacked and the blood lust is very keen; houses are freely invaded - the small size of the insects rendering ordinary mosquito netting ineffective in preventing their entrance. Their poison is extremely virulent and is far worse than that of Aedes vexans. The adults fly in the Lower Fraser Valley from the latter part of June to early August. After the end of August they die off and are only to be met with as odd stragglers except in the most sheltered places. The duration of adult life under normal outdoor conditions is probably from a month to six weeks.

Mating: Mating takes place early after the emergence. of the females. (The males usually emerge first). The males hover in a swarm of a few dozen to a hundred or so in sheltered places between the trees. At dusk, woods that are not too thick, are sometimes filled with these gyrating swarms. The females are attracted to the swarm and on entering are seized - the mated pairs then dropping out of the dance.

Number of Eggs Laid * 8.

To determine the number of eggs laid by Aedes aldrichi some dissections were undertaken in 1921. One hundred and ten dissections were made, but in arriving at the average number of eggs only those specimens were considered in which the eggs were from 1/2 to 3/4 developed. The averages are from 34 representative specimens :- Average number of eggs 68; Maximum 92; Minimum 36.

*8 NOTE:

Our investigations over three years show very decidedly that a single batch of eggs is the rule for Aedes aldrichi. That this may not always be the case however is indicated by a dissection of a specimen taken on July 26th, 1921. At the tip of the abdomenin this specimen was found a single fully developed white egg. The ovaries also showed a number of very minute eggs in an early state of development.

Development of Eggs: Dissections made at intervals between July 6th and August 11th, 1921, showed very slight development of the ovaries in the bulk of specimens during the period prior to July 22nd. From July 22nd, on, the majority of specimens examined showed development to be well advanced and in a number of cases eggs were ready for deposition by July 31st. In one or two specimens examined it was evident that eggs had been laid prior to July 6th.

Egg-laying: Some difficulty was experienced in persuading Aedes aldrichi to lay in captivity but we were successful on several occasions/

Three female aldrichi; taken at Hatzic on July 4th, 1921, while attempting to probe, were placed in a lamp chimney over a dish of silt and water. They were given a full feed of human blood on July 5th. The abdomens of the three specimens appeared similar and there was no sign of the white lateral patches indicative of egg development.

No.1 was dissected on July 12th and showed the blood to be about one half digested and the ovaries to be moderately well developed. A total of 78 eggs were found; 56 of these were about half developed and 22 were only slightly developed.

No.2 died on July 27th and dissections showed the blood to be completely digested. The abdomen contained almost fully developed eggs, and all were much in the same condition. Owing to damage in dissectionno count was made.

No. 3 laid 84 eggs on August 5th and then died. About 75 % of the eggs floated on the surface of the water and the remainder sank to the silt below - later all sank on the disturbance of the water.

In 1920 a number of Aedes aldrichi were caged and fed about July 15th. on July 22nd they were still biting freely and dissections showed a moderate ovary development in the most advanced. On August 1st only two of twenty specimens would probe and in most individuals the ovaries were all well developed. Some were fully developed and one female oviposited. She laid 74 eggs, the entire contents of her ovaries. The eggs were deposited singly and in irregular clusters on the water where they floated some days before sinking.

Description of the Egg: The eggs are white when first laid but soon turn jet black. The surface membrane has hexagonal reticulations in irregular rows. The shape is irregularly fusiform and somewhat resembles that of Aedes vexans but is shorter and stouter. It also tapers less sharply, and is more convex on one side.

Summary of Life History:

The winter is passed in the egg stage in the depressions in the Cottonwood bottom lands - at that time dry. On being covered with water (from the freshet floods) the eggs hatch and larval development proceeds, the adults emerging in about three weeks. Mating takes place shortly after the adults emerge and egg-laying takes place in about a month, the adults usually dying shortly afterwards. About 70 eggs are laid, these being placed singly and in loose clusters on the surface of the water. One batch of eggs only is the general rule.

Aedes cinereus Meigen * 9.

Aedes cinereus Meigen, Syst. Beechr. Eur.Zweifl.Gus. 1, 13,1878.

Recognition Marks: A very small, dark, slightly built mosquito. The mesonotum is reddish brown, and the legs and proboscis are black. The abdomen is black and each segment is clothed at its apex with a fringe of pale hairs. The venter is entirely white scaled and there is an unbroken lateral white stripe running the full length of the abdomen. The abdominal colouration is subject to some variation; and, while there may be transverse pale bands, most of the Fraser Valley specimens have the abdomen without dorsal bands.

Importance:

This species is of very little importance in the district. It is somewhat variable in its habits; at times being vicious and persistent in its attacks, and at other times showing the greatest timidity and caution. The poison is decidedly virulent but not so much as in Aedes aldrichi This is an extremely localised species and seldom moves far from its larval habitat; It is not strictly nocturnal.

*9. Agassiz, B.C. April 22nd, 1919.(E. Hearle)

Distribution:

Aedes cinereus occurs throughout the district wherever conditions exist that are suitable for its development. In general it is not a common species but in one or two restricted localities was found to be dominant and occurred in considerable numbers.

Breeding Places:

Although cottonwood flood swamps are the main places for this species it is far less restricted than Aedes aldrichi and larvae may be taken in shallow protected surface pools and ditches containing clean water. It mainly breeds in flood water in the Fraser Valley but also occurs in small numbers in early snow and rain pools.

Life History:

In general this appears to be much like that of Aedes aldrichi. The average number of eggs is 120. Winter is passed in the egg stage. The adults fly from June to August, keeping usually well in the shelter of cottonwood areas.

B. GENERAL BREEDERS:

The species below are very general breeders and may be found in permanent pools and swamps, as well as in semi-permanent and temporary bodies of water. Cottonwood swamps, roadside ditches and, at times, open flooded fields may contain numbers of these larvae. There appears to be a slight preference for permanent and semi-permanent bodies of water. The most generalized breeders are given first:- Culex tarsalis Coquillett; Anopheles punctipennis Say; Anopheles maculipennis Meigen; Culiseta inornatus Williston; Culex testaceous van der Wulp and Aedes excrucians Walker *10.

*10 Possibly may be Aedes fitchii Felt & Young.

Culex tarsalis Coquillett * 11.

Culex tarsalis Coquillett. Can. Ent.XXVIII,43,1896.

Recognition Marks:

This moderate-sized mosquito has a very striking and distinctive colouration. The dark proboscis has a broad crisp white band beyond the centre; the legs, also dark, have fairly broad white bands at the base and apex of the tarsal segments. The abdomen, which is brownish black above, has broad cream-coloured basal segmental bands. Ventrally there is a series of black V shaped marks. The thorax, mainly clothed with dark brown scales, has two pale stripes running forward from the base to two pale spots at the centre. The apex of the wing is tipped with golden scales but all the remainder are dark.

Importance:

This species is fairly common throughout the district but never occurs in great numbers like Aldrichi or Texans. It is one of the most painful of biters and the numb pain and swelling, following probing, lasts for hours. During the day tarsalis appears to hide in outhouses and other shelters; but at dusk it is very active and makes persistant efforts to enter dwellings in its search for blood.

Distribution:

The species was found to be very generally distributed in the Fraser Delta from Cheam View westward to the Coast. It was not found in the forested region north of the valley but only in the delta proper.

Breeding Places: This is one of the most general breeders we know. Larvae were taken from open surface rain pools, flooded fields, roadside ditches, sloughs, permanent swamps and ponds, and cottonwood flood swamps. No water can be too foul apparently and larvae were often taken in filthy pools in cattle yards. * 11. Chilliwack,B.C. May 20,1919.(E.Hearle)

Life History:

The adult females hibernate in sheltered places, the time of their emergence in the Spring depending upon weather conditions. In 1921 the early spring egg-laying occurred during the first two weeks in May, during which time egg-laying of the overwintered females was at its height - egg rafts and newly hatched larvae were very abundant. In 1919 the earliest adults from the first brood emerged from pupae on May 29th. Brood follows brood throughout the season and these over-lap so that egg-rafts, newly hatched larvae and full grown larvae and pupae may be taken together in one breeding place. The eggs are laid in rafts and the dissection of a gravid female showed 425 eggs in the ovaries, all being in the same state of development.

Anopheles punctipennis Say *12.

Recognition Marks.

This slim dark grey Anopheline is one of the easiest mosquitoes to recognise. The large yellow and black patches on the wings preclude the possibility of confusion with any other species in the district. The thorax has a very broad, median, grey stripe; the legs are very long and slender, and are unbanded, and the abdomen is dark grey - the abdomen is clothed with hairs and not scales.

Importance: Although the commoner of the two Anophelines in the district, punctipennis was not found abundantly enough to be considered very troublesome. Its poison is very virulent and it is persistent in its efforts to enter houses. Although it will on occasion bite in the daytime it is very seldom on the wing until dusk.

*12. Dr. S. Hadwen in 1915 recorded this as being the only Anopheles found in the Lower Mainland (Fraser Valley) but gave no specific data. Proc. B.C.Entl.Soc.No.5,p.81. (6).

The writer's first record is as follows:

New Westminster, B.C. April 9th,1919. (E. Hearle)

Distribution:

Specimens were taken from Hope to the Coast and the species is very generally distributed in the Valley, although we found it nowhere in very great abundance.

Breeding Places: Larvae were found in a number of very different types of breeding places - roadside ditches, surface pools; cottonwood flood swamps; permanent swamps; rain-filled pools and open depressions in meadows and in fact almost any place where water could collect, with the exception of artificial receptacles.

Life History: The females hibernate throughout the winter in cellars, outhouses, caves and other sheltered places. During 1919 the general emergence from hibernation quarters occurred during the last week in March, although individual specimens had doubtless emerged prior to this on especially warm days. Occasional specimens were taken biting throughout April and May. but no larvae were taken until May 21st - the first adults from these emerged on May 29th. In 1921 adults were taken early in April butno larvae were found until the latter part of May. From the experiments of various workers (13) & (14) it is evident that this species lays a large number of eggs - sometimes exceeding 2,000. The eggs are laid at different periods in batches of about 200. They are placed singly on the water close to each other and are kept from sinking by a membraneous float. Brood succeeds brood throughout the summer and a great deal of overlapping occurs.

Anopheles maculipennis Meigen * 13.

Anopheles maculipennis Meigen, Syst.Besch.Zwiefl. Ins. 1.11, 1818.

Recognition Marks:

This species, which appears frequently in literature under the name of occidentalis; may readily be distinguished from punctipennis by the difference in the wing marking. The wings have four black spots instead of the yellow and black markings that characterise punctipennis. The tip of the wing is golden scaled on the fringe.

Importance and Distribution:

This anopheline is less common in the district than punctipennis. The habits are very similar save that maculpennis appears more strictly nocturnal. Specimens were taken only in the area between Chilliwack and Mission, but the species is probably generally distributed throughout the valley.

Breeding Places and Life History:

The remarks under Anopheles punctipennis in general apply here. Larvae were taken in cottonwood flood swamps, shallow pools under willow growth and in permanent swamps and pools. Eggs are laid as in punctipennis and the time of emergence in the Spring and the life history in general appear to be similar in the two species.

* 13. Mission, B.C. April 26,1919.(E. Hearle)

Culiseta inornatus Williston * 14.

Recognition Marks: This is one of the largest mosquitoes in the district. It is a yellowish brown in colour and is somewhat hard to distinguish from Culiseta impatiens. although the latter is considerably darker. (The male genitalia offer excellent characters for separation.) The integument of the mesonotum is yellowish brown and the scales are brown and pale golden - the latter tending to form lines.

*14. Nicomen Island, B.C. July 27,1919. (E. Hearle)

The abdomen has broad basal bands of cream colour and the legs are unbanded and have a large proportion of pale scales, they darken at the tarsi where the pale scales become much less numerous. The wings are mainly dark scaled but there are many pale scales along the costal margin - some dark scales usually occur on the cross-veins. The proboscis is chiefly dark but has a sprinkling of pale scales.

Importance and Distribution:

This species is of very little importance in the district. It is comparatively rare and does not evince a keen blood lust as far as humans are concerned. Very few specimens

were taken but it is probable that the species is to be found in limited numbers throughout the district.

Breeding Places and Life History:

Larvae were taken from roadside pools and the edges cottonwood flood swamps. Howard, Dyar and Knab (15), mention the following breeding places ; permanent water, pools in streams, or spring holes, pools formed by cutting off portions of a lake by refuse, abandoned well holes, rain barrels and transient bodies of water. The adult females hibernate in sheltered places and have a habit of coming out to fly for a day or two in particularly fine weather during the winter months, sometimes even when snow is on the ground. This has given rise to the name snow mosquito which is locally applied to this species and Culiseta impatiens. On the spring emergence a large boat-shaped egg-raft is laid, the larvae hatching from this developing somewhat slowly. There are several broods.

Culex testaceous van der Wulp: *15.

Culex testaceous van der Wulp, Tidsch, Voon Ent. 2. Vol.10. p.128,1867.

Recognition Marks:

This species has been widely discussed in literature under the names of Culex territans; Culex saxatillis. and Culex apicalis. It is a very small dark mosquito. The abdomen, which is black, has crisp white segmental bands, these are situated at the apex of the segment, a feature which distinguishes it from any other B.C. mosquito. The thorax is clothed with fuscous brown scales and the legs and proboscis are dark and unbanded.

Importance and Distribution:

To our knowledge Culex testaceous is absolutely non-predacious as far as man and other warm blooded vertebrates are concerned, but Dr. Dyar states that they have been observed attacking frogs. (16) Specimens were taken between Pitt Meadows and Agassiz, and larval collections showed the

species to be very generally distributed in the district and to be fairly common. They are however very localized and seldom move from their breeding places.

Breeding Places and Life History:

Larvae were taken in shallow surface pools protected by willow growth, open meadow swales, roadside pools and ditches, permanent swamps and cottonwood flood swamps. Breeding places noted elsewhere are rock pools, clear woods pools, springs, rainwater barrels, and the grassy edges of streams. In our experience there is a very decided preference for clean water.

* 15. Vancouver, B.C. April 22, 1917.(R.S.Sherman)
Pitt Meadows B.C. June 7th,1919. (E. Hearle.)

The earliest adults taken in the Spring were obtained early in April (1917 R.S. Sherman) and the writer took adults from June to late October. There are a number of broods throughout the season and these overlap so that all stages may be taken at the same time from Spring to late Fall. The adult females hibernate but may fly on especially fine days. Mr/Sherman has specimens which he took in December. This species does not appear to favour buildings and outhouses for their winter quarters, but have been taken hibernating among the crevices in stones overhanging a spring in the woods (17). Eggs are laid in small rafts of about 130.

Aedes excrucians Walker: * 16.

Culex excrucians Walker, Ins. Saund. 429,1856.

Recognition Marks.

This is a fairly large mosquito with rings at the bases of the tarsal segments - the rings on the hind legs being very broad. The thorax is ornamented with a concrete broad reddish brown stripe and posterior stripe of the same colour. The abdomen is black with white bands at the base of the segments. The colouration is very similar to Aedes mutatus which is however a very much smaller species.

Importance and Distribution:

A single specimen only came to hand in three years collecting and the species is probably never anything but very rare in the valley.

Breeding Places and Life History: One full grown larvae came to hand - this was taken in vegetation bordering the edges ofa slough. Pupation occurred on June 17 and the adult - a female- emerged four days later.

*16. Hatzic, B.C. June 15th 1919 (E. Hearle). Aedes fitchii felt & Young may be the species referred to here as in the adult female the two species cannot be distinguished with certainty.

Unfortunately the vial containing the larval and pupal exuvia was mislaid before a determination was made and we cannot be certain from the one female specimen on hand whether this was Aedes excrucians or fitchii.

C. Rainwater Barrels and other Artificial Receptacles:

The two species dealt with under this heading, although very general breeders, showed a marked preference for rainwater barrels. Almost every barrel in the district, that was examined, gave great numbers of Culiseta incidens Thompson/. Larvae of Culex pipiens Linnaeus were not taken, but our experience elsewhere indicates that rainwater barrels are the favourite breeding places of this species.

Culiseta incidens Thompson: *17.

Culex incidens Thompson, Kongl.Sven.Freg.Eug.Pesa.VI.Dipt.443.1886

Recognition Marks: This very large dark Culiseta may be recognised by the black spots on the wings; these are at the base of the forks of the second and fourth veins and at the base of the second vein. The cross veins are without scales. The abdominal segments have basal white bands and the legs have very small indistinct pale rings at the base of the tarsal segments. The thorax is clothed with very dark scales and a small proportion of pale scales which

form a pair of diffused stripes running forward from the base and enlarging at the middle of the mesonotum to form a pair of median spots.

Importance and Distribution: This species is of practically no economic importance owing to its timidity. The blood lust appears to be only very slightly developed as far as humans beings are concerned. Even if a female has settled on one's hand and is probing, it will fly off at the least movement. A rainwater barrel against a house may be breeding thousands, but few will be found indoors.

*17. Vancouver, B.C. Aug. 16,1903(Dyar & Caudell)
Agassiz, B C.April 22,1919. (E. Hearle)

Culiseta incidens occurs practically everywhere in the Fraser Valley. It is the most widespread mosquito in the district, and one of the commonest; although its retiring habits make it less noticeable than more aggressive species.

Breeding Places:

This is the common domestic mosquito of the district. The chief breeding places are in rain-water barrels and almost every barrel examined was found teeming with larvae throughout the summer. The species is however by no means restricted in its choice of breeding places and few mosquitoes show such diversity of larval habitats. Larvae were taken along the coast in dirty salt water pools,*18 . in company with Aedes dorsalis. They were found in filthy ditches, ponds, in clean woodland pools, in open sloughs, rain-filled depressions in woods, and in the edges of cottonwood flood swamps.

Life History: The adult females pass the winter in hibernation in sheltered places. Some flying may occur on warm days during the late winter, but general emergence from winter quarters does not occur until March or April. In 1921 extensive egg-laying from overwintered females occurred between April 1st and May 5th.

* 18. Na.Cl. .760% by weight as compared with sea waters 1.234%. Analysis by W.H. Hill, Dom.Public Health Dept. Vancouver.

Culiseta incidens (Continued)

The egg rafts contain a very large number of eggs. Development occupies about a month and brood succeeds brood until the fall frosts occur. There is much overlapping of broods and all stages may be met with at the same time during the summer months.

Culex pipiens Linnaeus. * 19.
Culex Pipiens Linnaeus, Syst. Nat. ed. X, 602,1758.

Recognition marks: This is a medium sized brown mosquito whose most distinctive feature is the lack of any very characteristic markings. The size and colouration are subject to much variation- the colour is usually reddish brown but many specimens are dusty brown.

*19. Vancouver B.C. Jan.11,1917)R.S. Sherman)
Vancouver B.C. Aug.23, 1919. (E. Hearle)

The legs and proboscis are clothed with dark brown scales and the mesonotum is wholly brown scaled. The white basal abdominal bands are moderate in size and on the second sgement the band is triangularly expanded at the centre. The wing scales are entirely dark and are somewhat narrow.

Importance and Distribution:

Culex pipiens is the common house mosquito or gnat of Europe and is very persistent in its efforts to enter dwellings - it is one of the most domesticated of all mosquitoes. Where it is abundant it is an extremely annoying pest and is of considerable importance.

In British Columbia this species has been taken at one point only, Vancouver; and during three years investigations less than a dozen specimens have come to hand. It would appear that this species has been introduced comparatively recently. Dyar states that the introduction into California was from Japan. (18). Conditions in the Fraser delta appear ideal for the development of this species and as time progresses it may become an important factor in the mosquito pest. At the present time, it is, of course, negligible on account of its scarcity.

Breeding Places: No larvae of this species have come to

hand in this district, but there is no reason to expect any variance in the habits of the species as recorded from other places. Rain-water barrels and other artificial receptacles are the favourite larval habitats. Catch basins, tin cans and broken bottles are among other breeding places recorded. Ground pools often breed numbers and no condition appears too foul for this species.

Life History:

Little data is available for British Columbia but the life history is probably very like that of Culiseta incidens although development may possibly be somewhat more rapid. Specimens were taken in Vancouver in January, March, April, May, August, September and October. The following notes are from our own experience of this species in Ontario and from Headlee (19) of New Jersey. The winter is passed by the adult female in cellars and other protected places. The emergence from hibernation quarters occurs in the Spring as soon as warm weather sets in and egg-rafts are deposited wherever standing water is available. The egg rafts are composed of from 40 to 500 eggs. Larval development under optimun conditions may be complete within a week and the pupal stage may occupy as little as from one to three days. Successive broods follow each other throughout the summer until cold weather occurs. According to Dyar (20), freezing is fatal to eggs, larvae and pupae. This species normally does not fly many hundred yards from its breeding place, but migrations of a little over two miles have been recorded under exceptional circumstances.

D. FOREST AND MOUNTAIN MOSQUITOES:

Several members of the Fraser Valley mosquito fauna are restricted to wooded areas and are seldom taken elsewhere, either as larvae or adults. They mainly breed in woodland pools, but one species breeds in rain-filled cavities in trees. Aedes punctor Kirby; Aedes aboriginis Dyar; Aedes lazarensis Felt & Young; Aedes canadensis Theobald; Aedes varipalpus Coquillett;

Forest and Mountain Mosquitoes (Continued)

Culiseta impatiens Walker; Aedes cataphylla Dyar; and Aedes aloponotum Dyar, are the species that may be considered to be restricted to woodland habitat. These are the species mainly met with on wooded mountain slopes, although they also occur in dense forested areas of lower elevation.

Aedes punctor Kirby *20
Culex punctor Kirby, Richardsons Fauna Nor.Am.IV,309,1837.

Recognition Marks:

This is a medium sized to large mosquito. The mesonotum is clothed with golden brown scales and has a broad band of dark brown scales centrally and a dark area posterially on each side. Considerable variation is met with in the thoracic ornamentation and a definite diagnosis is not always possible with some female specimens. The legs and proboscis are black, and the abdomen is black with narrow, crisp, white basal bands, The wing scales are entirely dark.

Importance and Distribution:

This species is a fairly bad biter but the effects seldom last long. It remains in the shelter of trees, and in deep woods will bite throughout the day. It is to be found throughout the district, specimens having been taken from Hope to Vancouver. Under Fraser valley conditions we have found the species to be extremely localised - it may occur in great numbers in one or two places and within half a mile be comparatively scarce. In the delta in general it is not common, but it is the dominant species breeding in the wooded country adjacent to the valley proper. Even so it is seldom sufficiently abundant to be really troublesome.

Breeding Places and Life History:

Shallow woodland pools were the only breeding places in which larvae were found. The earliest emergence noted from the spring pools was on April 23rd, 1919. There is only one brood a season but adults may be met with from April to August.

* 20 Agassiz,B.C.April 22,1919(E.Hearle)

At an elevation of about 3,000 feet, emergence does not occur until about July. On July 18,1920, a trip was made to the summit of a mountain (about 3,000 feet) some 12 miles from Hatzic. On the summit a level plateau occurred with little vegetation, some tufts of grass, and red false heather(Phyllodoce empetriformis Don.) The melting snow had caused numerous pools to form in the depressions but the water had nearly evaporated or seeped away at the time of our visit. A swarm of Aedes punctor recently emerged and evidently bred in the snow pools was encountered on the plateau. They attacked fiercely and followed us in a large swarm, but the numbers diminished as we descended the mountain and but few were seen when the base was reached.

Aedes aboriginis Dyar * 21.

Aedes aboriginis Dyar, Ins.Ins.Mens.Vol.V.p.99,1917.

Recognition Marks:

This is a large robust Aedes with the mesonotum golden brown, with broad paired median lines of a darker brown shade. The abdomen is black with concrete white bands at the base of each segment. The proboscis and wings are black scaled and the legs are mainly black scaled in the tarsi. In some forms adults of this species cannot be separated from Aedes punctor, or Aedes lazarensis. The male genitalia are similar to Aedes punctor but the larvae are different from either of the above.

Importance and Distribution:

This is a rare mosquito in the district in general but was found to be fairly common in places in the deep forest area north of the valley proper, where a number of specimens were taken - a single specimen was also taken in deep woods near Port Coquitlam. The species is of little importance,being neither very vicious or persistent in its attacks.

Breeding Places and Life History: The larvae evidently develop in early snow pools in deep woods but we were not fortunate enough to secure specimens.

* 21. McConnell Creek, B.C., 18. VI. 1921. J. Heagle

Aedes aboriginis (Continued)

Adults were found in greatest numbers about the middle of June and were much scarcer by the middle of July.

Aedes lazarensis Felt & Young * 22.
Culex lazarensis Felt & Young, Science N.S.Vol.20,p.312,1904.

Recognition Marks:

This is a fairly large mosquito of much the same build as Aedes punctor Kirby. The mesonotum is clothed with straw-coloured scales and is ornamented with a median pair of dark lines - these are fairly broad and may be moderately distinct or diffused and are divided by a pale stripe of the same width as each dark one. There is also a fairly short posterior dark stripe on each side. The abdomen is dark scaled with concrete white bands at the base of each segment. The legs and proboscis are black and the wings are entirely black-scaled. The mesonotal ornamentation is subject to such variation that diagnosis is not always possible from female specimens. The male genitalia, however, have specific characters that prevent confusion with other Fraser valley species.

Importance and Distribution:

Aedes lazarensis is a very rare mosquito in the Fraser Delta, only three or four specimens having come to hand during three years collecting - one of these is fortunately a male and there can be no doubt as to identity. The specimens were taken at Hatzic, Nicomen Island, and Davis Lake.

* 22. Nicomen Island, B.C. July 8th, 1921 (E. Hearle)

Breeding Places and Life History:

Of the many hundred larvae collected between 1919 and 1921 only two proved to be Aedes lazarensis. A larval sample taken from a flood pool in cottonwood bottom lands on Nicomen Island on July 8th, 1921, gave large numbers of Aedes aldrichi and Aedes vexans adults; among them were two Aedes lazarensis Felt & Young - a female and a male which emerged on July 8th and 13th respectively.

We have dealt with this species under woodland mosquitoes as this is the usual habitat throughout most of its main range. Dyar states, however, that in the Skeena Valley it is the dominant species breeding in flood pools (21), and possibly in the Fraser Valley it may be more a flood pool species than a typical woodland mosquito. The life history is probably much as in Aedes punctor where wood pools are the habitat - the eggs hatching in the snow pools earlym in the spring. In the case of flood pool larvae the life history would probably resemble that of Aedes aldrichi.

Aedes canadensis Theobald: *23.

Culex canadensis Theobald, Mon. Culia. 11, 3, 1901.

Recognition Marks:

Tuis is a fairly small brownish mosquito with crisp white bands on the apex and base of the tarsal segments - these are most distinct and broad on the hind legs, the ultimate segment is entirely white. The mesonotum is golden brown and the abdomen is black, as is the proboscis. The wing scales are entirely dark.

Importance and Distribution:

In the valley proper only a few specimens of this species came to hand during our investigations. They were taken in woods at Dewdney, Mission and above Hope, between July 19th and September 10th. In isolated places in the area adjacent to the Valley this species may possibly occur in some numbers. In 1920 a sample of mosquitoes was sent down from a lumber camp at Silver Creek, Harrison Lake, where a serious pest had developed. Many hundred specimens had been placed in a small bottle and only fragments remained when the shipment was received. It was evident from these that a moderate proportion of the specimens had been A. canadensis.

* 23 Mission, B.C. September 10th, 1919 (E. Hearle)

Breeding Places and Life History:

Our experience of this species has in its main range has been that it breeds in woodland pools, wintering in the egg and developing on the filling up of the pools. Freshly emerged adults may be found at various times during the summer but Dyar states (22) that this is probably not owing to the occurrence of several generations but that all eggs do not hatch at the first filling of the pools. The species appears to be very localised and is restricted to woodlands. It is a severe biter.

Aedes varapalpus Coquillett: *23. * 24.

Culex varapalpus Coquillett, Can. Ent. XXXIV p.292, 1902.

Recognition Marks:

This is a small beautifully marked black and white species. The thorax is clothed with black and white scales arranged in a variable pattern of spots and indistinct lines. The legs are black with white bands at the apex of the tarsal segments; on the hind legs the bands are very broad and the ultimate segment is entirely white, in the penultimate segment the white band is at the base. The abdomen is black with crisp white basal bands. The wings are heavily clothed with dark scales.

Importance and Distribution:

This mosquito is of little importance in the district as it is never met with in any numbers. The bite is fairly painful but the females show great timidity in approaching to probe/ The species is very generally distributed and the writer took specimens at Hope, Harrison Hot Springs. Deroche, Hatzic Prairie, Kilgard, Capilano and Caulfield.

Breeding Places and Life History:

Rain filled cavities in trees are the main breeding places of this species but larvae may be also found in artificial receptacles. The writer took larvae in a water barrel on a bridge over a mountain stream at Hope. The larvae are very distinctive as they have enormously inflated oval leaf-like gills. Little is known of the life history. The winter is passed in the egg stage

but nothing is known as to the number of broods, etc. The larvae mentioned above were about 3/4 grown on May 20th. Adults were taken from June to August. Unlike any other B.C. mosquitoes the males are attracted to warm blooded animals/ They do not bite but hover around waiting for the females to approach - we have observed copulation to take place while the female was settled feeding.

* 24.Vancouver B.C. Aug. 6th,1906. Dyar.
Hope B.C. May 20th,1919. (E.C. Hearle)

Culiseta impatiens Walker *25.

Culex impatiens Walker, List Dipt.Brit.Mus.1,5,1848.

Recognition Marks:

This is a very large dark brown mosquito somewhat hard to distinguish from Culiseta inornatus. in specimens that are not perfect. The chitin of the thorax is dark brown and the scales are brown except for a few pale ones that form two median spots and two indistinct lines running back posteriorly from these. The abdomen is dark with pale basal segmental bands. * 25 Agassiz, B.C. June 1,1917 (A.E.Cameron)
Duman, Lord C.K., 1866
Caulfields B.C. May 3,1919(E. Hearle)

The legs are dark and unbanded; and the wings are entirely dark scaled and lack scales on the cross veins. The proboscis is black.

Importance and Distribution:

This species is usually too timid and hesitating in its attacks to be considered of much importance. In the spring on emergence from hibernation quarters it may bite fiercely for a few days. Wooded mountain slopes at several thousand feet gave more Culiseta impatiens than other places, but the species is fairly common and widely distributed throughout the valley - very few were taken away from the protection of trees. Specimens were taken from Caulfields on the coast to Hope at the mouth of the Fraser Canyon.

Breeding Places and Life History:

Dyar (23) states that the larvae of Culiseta impatiens live in dark permanent forest pools. We have taken them in the Fraser Delta also in shallow pools beside the railways where willow protection occurred, and in road side pools dirty with much rusty discolouration.

The species winters as the adult female and, in common with other Culiseta of the district, is probably one of those locally known as snow mosquitoes, from the habit of occasionally emerging on warm days in the winter even when snow is on the ground. The general spring emergence from hibernation quarters was in the last week in March in 1919. Eggs are laid in large rafts and there are a large number of generations during the season. Our specimens were taken between March 25th to June 22nd.

Aedes cataphylla Dyar *26.
Aedes cataphylla Dyar, Ins. Ins. Mens. Vol.IV, p.86, 1916.

Recognition Marks:

This is a small dark grey species with a somewhat rough appearance due to the number of dark bristles and coarse scales. The thorax is frosty grey (chitin black), and the abdomen is black with white basal bands. The legs are dark and unbanded and have a scattering of pale scales. The proboscis is entirely dark scaled and the wing scales are dark.

Importance and Distribution:

This species is too rare in the Fraser valley to be of any importance. It is not likely to be met with except at some height on mountains as it is primarily a northern and high altitude species (it is dominant at such places as Banff and Lake Louise). In the Fraser Valley it has been identified with certainty only from Mount Cheam but the writer took specimens of what appears to be this species near North Vancouver on May 2nd, 1919.

Breeding Place and Life History:

The larvae probably breed in snow pools in the mountains, the winter being passed in the egg stage and the adults emerging at different times at different elevations.

Aedes aloponotum Dyar. *27.
Aedes aloponotum Dyar, Ins. Ins. Mens. Vol.5 p.98,1917.

Recognition Marks:

This is a very large reddish brown Aedes, in which the legs are crisply and broadly banded with white at the base of the tarsal segments. The abdomen is black and has broad cream-coloured transverse basal bands, and usually some pale scales along the apical edge of the segments. The integument of the thorax is reddish brown and the mesonotum is clothed with scales of the same colour. The wings are clothed with dark scales save for a few pale scales along the costal border.

Distribution, Importance and Bionomics:

Specimens were taken from Hope to Mission and the species appears to be fairly generally distributed in the district. It was seldom met with outside woods, and on one occasion when a large number were under observation at 10 2.m. it was found that although they would bite fiercely in the shelter of deep woods they did not follow into the open. The species appeared to be very localised and was only abundant in one or two places - at Popgum large numbers, evidently fairly recently emerged, were met with in deep woods in the last week of May. Our specimens were taken between May 19th and August 3rd. During the three years collecting but one male came to hand - this was taken at Mission on May 19th,1920, but through an accident the abdomen became broken before a slide of the genitalia had been prepared.

* 26 Mount Cheam B.C. Aug. 7th (J. Fletcher)

* 27 Hope B.C. May 21st, 1919 (E. Hearle)

E. GRASSY MARSHES:

The two species occurring in the valley which usually breed in this type of habitat are Aedes flavescens Muller and Culiseta alaskaensis Ludlow. We have never taken larvae in the Fraser valley, but this larval habitat has been indicated from the preference of the two species in other sections.

Aedes flavescens Muller, *28
Culex flavescens Muller, Faun.Ins.,Friedrichdalina,p.87,1764.

Recognition Marks:

This is a very large yellowish species which until recently appeared in American literature under the name Aedes fletcheri Coquillett. The colouration is typically as follows:- the abdomen is suffused with yellow scales - these usually covering the segments to the exclusion of all save a few scattered black ones. The mesonotum is clothed with golden brown scales shading to golden ones at the sides. The legs are broadly banded at the base of the tarsal segments. The femur and tibia are largely yellow scaled, as are the wings/

Importance, Distribution, Breeding Places, etc.

No specimens at all of this species came to hand during our investigations and the only record is that of the specimen taken on Mount Cheam by Dr. Fletcher. Dyar (24) refers to this as a normally marked fletcheri (i.e.flavescens) Our experience elsewhere indicates that this species breeds mainly in open grassy swamps of a more or less permanent nature. In Banff it was found to be dominant in this type of habitat. Dyar (25) gives ground pools as the breeding places.

* 28 Mount Cheam, B.C. August 3rd,1899 (J. Fletcher)

Culiseta alaskaensis Ludlow: *29.

Thaobaldi alaskaensis Ludlow, Can. Ent.XXXVIII,326,1906.

Recognition Marks:

This is the largest of the Fraser valley mosquitoes. The colour is a very dark brownish black and the legs are fairly broadly ringed with white at the bases of the tarsal segments. The integument of the mesonotum is very dark and the vestiture is somewhat sparse and consists of scattered black and straw-coloured scales. The abdomen is black with fairly broad basal segmental pale bands. The proboscis is dark brown. The wing scales are mainly dark but some pale scales occur along the costal margin, there are indistinct spots on the wings and the cross veins usually have some scales on them.

Importance, Distribution, Breeding Places, etc.:

Apart from its extreme rarity in the district this species is of little importance as it is timid in attack and is a poor biter. A single specimen only has been taken in the district.

Dyar (26) states that the larvae live in grassy marshes, generally in river ~~swamps~~ valleys. The adults pass the winter, hiding in hollow logs and similar locations, and appear very early in the Spring. The eggs are deposited in rafts on the surface of the water.

F.PERMANENT SWAMPS CONTAINING MUCH MATTED VEGETATION:

These areas are comparatively scarce in the valley - the majority of swamp areas are temporary and are dry except during and following the freshet season. Permanent swamps with a dense mat of vegetation, as sometimes found in old disused beaver dams provide conditions suitable for the development of one unique mosquito - Mansonia perturbans Walker. Occasionally anopheline larvae may also be taken in this type of habitat.

* 29 Hope, B. C. May,20th,1919 (E.Hearle)

Mansonia perturbans Walker: *30.
Culex perturbans Walker, Ins.Saund; Dipt. 428,1856.

Recognition Marks:

This is a medium sized stoutly built brown mosquito with a very striped appearance. There are broad pale bands at the base of the tarsal segments and a broad pale band at the distal quarters of the hind tibiae. The proboscis has a very broad pale diffused band and the abdomen has basal segmental bands of creamy white. The wings are very distinctive, having a dusty appearance owing to the mixed dark and pale scales with which they are clothed; these scales are characteristic , being very broad. The thorax has dusty brown scales in contrast to the darker brown vestiture of the abdomen, proboscis and legs.

Importance and Distribution:

This species was found in numbers in only one or two isolated places. Throughout most of the valley it is very rare. It is an extremely vicious biter and the attentions of a few perturbans can create more discomfort than the bites of large numbers of most other species. No other mosquito that we are acquainted with has such virulent poison. It shows no timidity in attack and is very persistent in its efforts to enter houses.

The species appearss to occur throughout the district, although sparsely except in one or two localities. Specimens were taken from Vancouver to Nicomen Island. In the vicinity of the old beaver dam at Stanley Park, Vancouver, it was found to be the most abundant mosquito.

Breeding Places and Bionomics:

No larvae were found, but the habits and habitat of the larvae are well known owing to the work of Mr. Brakeley of New Jersey (29).

*30 Hatzic B.C. July22,1919 (E. Hearle)

Permanent marshes and ponds containing much vegetation are the favourite breeding places. The larvae are very interesting as the breathing apparatus is so modified that they can obtain the necessary oxygen from the submerged stems of plants (sedges). The pupae also remain under water until t time for emergence. The winter is passed in the larval stage, the larvae clinging to the submerged stems and remaining unaffected even when frozen/ In the Spring, development, continues irregularly and apparantly very slowly, as the adults are scarce early in summer but gradually increase later. There is only one brood a year.

The above is summarised from Mr/ Brakeley's data an d applies to New Jersey condition, but there is no reason to believe that the life history varies from this in British Columbia. Our Fraser valley specimens were taken between July 7th and August 27th. They were noticeably more abundant in the latter part of this period.

G. SALT MARSHES AND COASTAL ROCK POOLS:

At the western extremity of the Fraser valley, along the coast, there are to be found rock pools containing brackish water. The main species breeding in these pools is Aedes dorsalis Meigen although Culiseta incidens Thompson is also to be found here. Salt Marsh areas are fairly rare in the district but wherever they occur Aedes dorsalis may be abundant.

Aedes dorsalis Meigen : *31.
Culex dorsalis Meigen, Syst.Bsch.bek.Eur.Zweifl.Ins.Vol.6, p.242,1830.

Recognition Marks:

This is a very beautiful fawn coloured mosquito of medium size. The legs have pale bands at the base and apex of the tarsal segments - the remainder of which are brown. The abdomen has pale basal segmental bands, and in addition

there is a broad central longitudinal stripe - the black scales are thus reduced to form small lateral squares.

*31. Vancouver, B.C.Aug.6,1906 (Dyar & Caudell)
Caufields B.C. May 3rd,1919 (E. Hearle)

The mesonotum is fawn coloured with a median reddish brown stripe. The proboscis is entirely dark. The wing is clothed with pale and dark scales mixed evenly; except on the third vein and the distal ends of the second and fourth veins in which the scales are mainly dark.

Importance and Distribution:

The limited distribution of this species renders it of comparatively little importance in the Fraser Delta in general; although, as it is a bad biter, it may in places be fairly troublesome to campers/ It is restricted in this district to the sea coast and outlying islands and was never found far from salt water. Our specimens were taken along the coast from White Rock to Caulfields and also from an island some hours out from Vancouver (Buccaneer Bay.)

Breeding Places and Bionomics:

Larvae were taken from coast rock pools of high salinity (Na.cl..760 as compared with sea water -(Pacific) - Na.cl.1.234). At Duncans, Vancouver Island, extensive breeding was found in a large salt marsh. The winter is passed in the egg stage. Specimens were taken between May 3rd and August 26th and larval collections gave emergences on May 7th and June 6th from the same pool.

H.ROCK BOUND RIVER CANYONS:

Part of the deep rocky gorge known as the Fraser Canyon was included in the territory embraced in the survey. In this habitat a characteristic mosquito was found to occur that was found nowhere else in the valley. This species Aedes mutatus Dyar was the only mosquito at all common in the Canyon.

Aedes mutatus Dyar. *32. #33.
Aedes mutatus Dyar. Ins. Ins. Mens; Vol.7, p.24,1919.

Recognition Marks:

This is a very small dark ring-legged Aedes. The mesonotum has a broad central stripe and sublateral posterior stripes of dark brown scales - the remainder of the thoracic scales are dirty white. The abdomen is dark with concrete basal segmental bands of creamy white scales. The legs have concrete white basal bands on the tarsal segments - these being especially broad on the hind legs. The wings are mainly clothed with dark scales but there are a few pale scales along the costal border. The proboscis is black .

This species is one of a number that are similar in the female colouration. Aedes excrucians is the only one occurring in the valley with which this is likely to be confused and the two can be readily separated on account of the difference in size. The male genitalia are diagnostic.

Importance and Distribution:

This mosquito is too localised to be of importance although it is a bad biter and attacks freely at dusk and through the night. It was encountered in only one district - Yale - but here it was dominant although not abundant.

Breeding Places and Bionomics:

No larvae were found but a careful search for breeding places indicated that the species bred in the rock pools filled by the rise of the river at freshet time. Culiseta incidens Thompson breeds in them very extensively and examination showed few other breeding places to be available. The high freshet usually occurs from the middle to the end of June. The earliest specimens were obtained on July 19th,1920, at this date nothing but males were found indicating recent emergence. The latest collecting was on August 8th when nothing but females were on the wing. Dyar (28) states that the "larvae live in pools along the rivers, following the high water of Spring."

* 32. Yale, B.C. August 3rd,1919 (E. Hearle)

#33 NOTE:

This form was described by the writer under the name Aedes hewitti (29) on a supposed difference in the genitalia. It appears however, that no anatomical differences can be demonstrated and the writer referred hewitti to the synonomy of Mutatus (30). Dr Dyar however, finds in Colorado that in the upper river valleys a uniformily smaller form (as at Yale, B.C.) occurs than in lower areas and thinks that an insipient racial difference may possibly be indicated. (31).

LIST OF FRASER VALLEY MOSQUITOES ARRANGED IN NATURAL SEQUENCE.

By way of a summary, a list of the Fraser Valley mosquitoes is given showing their systematic position and comparative abundance. In the arrangement we are following Dyar (32)

G E N U S C U L E X L I N N A E U S.

SUB GENUS NEOCULEX DYAR:

Culex testaceous van der Wulp	Fairly Common.

SUB GENUS CULEX LINNAEUS:

GROUP PIPIENS.

Culex pipiens Linnaeus	Rare.

GROUP TARSALIS.

Culex tarsalis Coquillett	Fairly Common.

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G E N U S C U L I S E T A F E L T:

SUB GENUS CULISETA FELT:

Culiseta alaskaensis Ludlow	Very Rare.
Culiseta incidens Thompson	Very Abundant.
Culiseta impatiens Walker	Fairly Common.
Culiseta inornatus Williston	Fairly Common.

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G E N U S M A N S O N I A B L A N C H A R D:

SUB GENUS COQUILLETTIDIA DYAR:

Mansonia perturbans Walker	Fairly Rare.

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G E N U S A E D E S M E I G E N:

SUB GENUS HETERONYCHA LYNCH ARRIBALZAGA:

GROUP PUNCTOR.

Aedes punctor Kirby	Fairly Common.
Aedes aboriginis Dyar	Rare.
Aedes aldrichi Dyar	Very Abundant.
Aedes cataphylla Dyar	Very Rare.
Aedes lazarensis Felt & Young	Very Rare.

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GROUP DORSALIS:

Aedes dorsalis Meigen	Fairly Common.
Aedes canadensis Theobald	Very Rare.

GROUP STIMULANS:

Aedes excrucians Walker *34	Very Rare.
Aedes mutatus Dyar *35	Fairly Rare.
Aedes flavescens Muller	Fairly Rare.
Aedes aloponotum Dyar	Fairly Common.

SUB GENUS TAENIORHYNCHUS LYNCH ARRIBALZAZA.

Aedes varipalpus Coquillett	Fairly Common.

SUB GENUS ECCULEX FELT:

Aedes vexans Meigen	Very Abundant.

SUB GENUS AEDES MEIGEN:

Aedes cinereus Meigen	Cpmmon.

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G E N U S A N O P H E L E S M E I G E N:

SUB GENUS ANOPHELES MEIGEN:

Anopheles punctipennis Say	Fairly Scarce.
Anopheles maculipennis Meigen	Fairly Scarce.

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* 34 Possibly Aedes fitchii.

* 35 Race of Aedes increpitus.

C. THE CONTROL OF THE LOWER FRASER VALLEY MOSQUITO PEST.

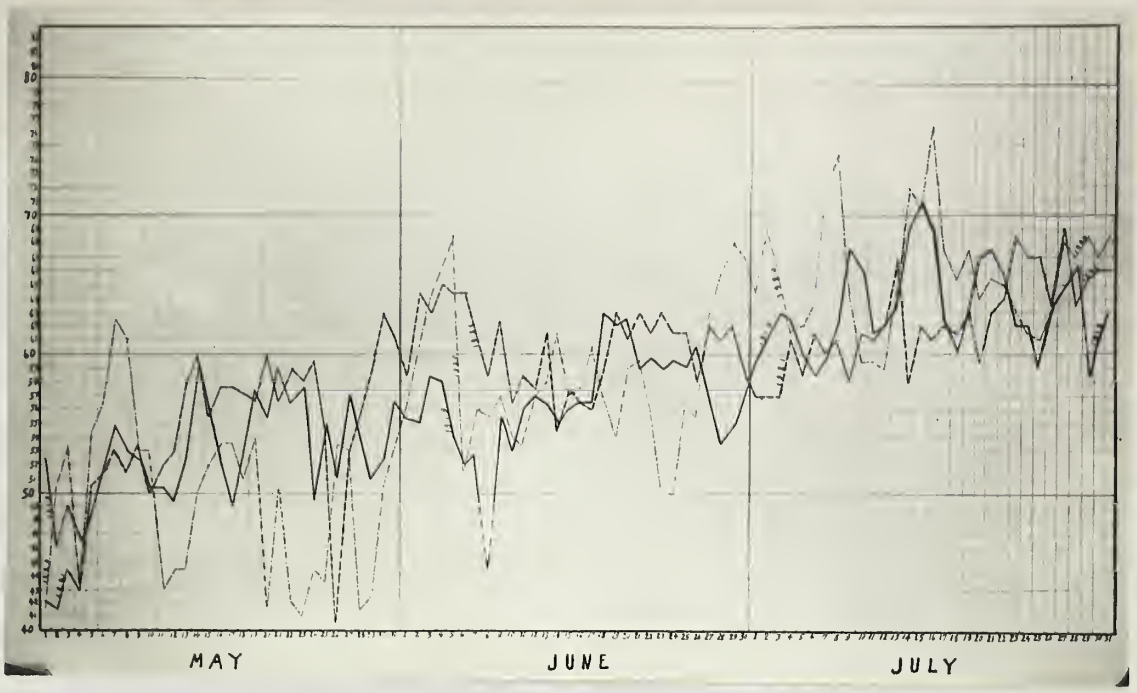
I. GENERAL CONDITIONS:

(a) Factors Determining Mosquito Abundance in the Valley - Synopsis and Comparison of Conditions for three years 1919 - 21.

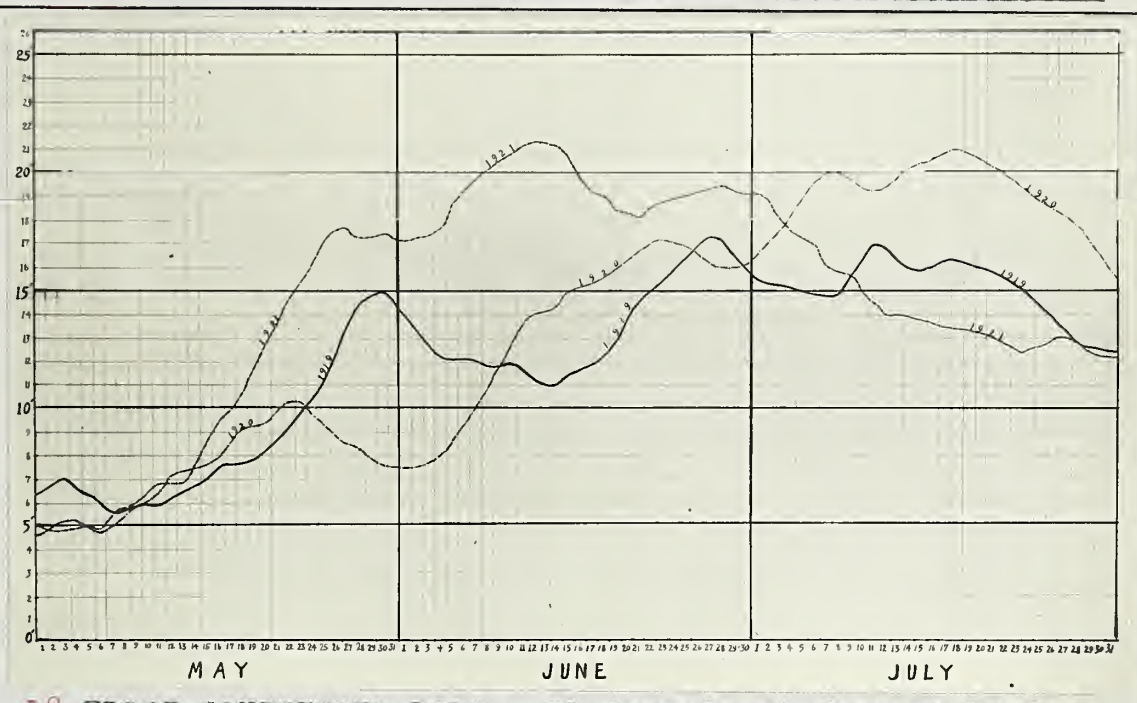
We were particularly fortunate in the conditions that obtained during the three years of the investigation. Each season provided a different set of conditions and the combination permits of deductions indicating the factors responsible for mosquito abundance in the valley - 1919 was an example of conditions when insufficient flooding occurred to result in a mosquito outbreak ~~cause a pest;~~ 1920, with its extensive floods and suitable conditions for mosquito development was a typically bad mosquito season and 1921 indicated the importance of climatic and other factors besides the actual flooding of the breeding areas.

1919 - Mosquito Conditions. During this year the river freshet did not attain sufficient height to cause much flooding. The highest level was 17' on June 27th; the water dropped to 15' within eight days and the weather during and following the freshet period was comparatively cold. On June 25th, when the freshet was within a foot of its peak, a survey of what areas were flooded showed large numbers of newly hatched larvae; many of these died before they had reached full growth. One very low lying meadow that was under close observation was flooded on May 26th at a river level of 12' 6". The general emergence of adults here occurred on June 12th - 18 days after the hatching of the eggs.

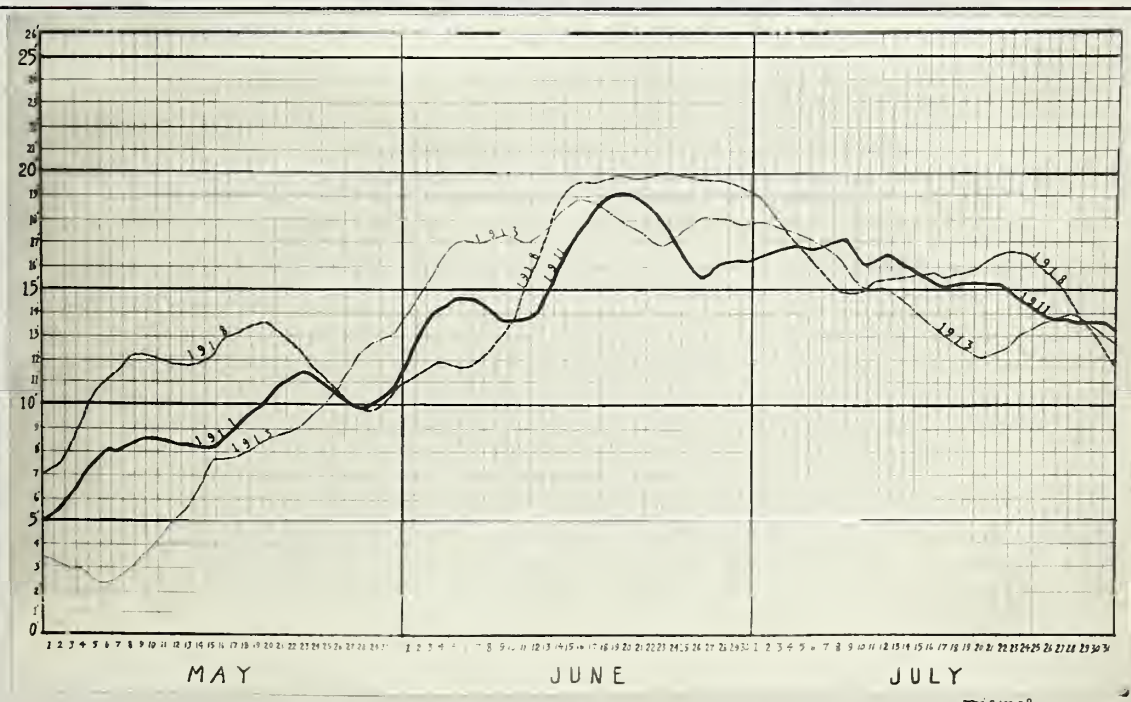
1920 - Mosquito Conditions: A height of 17' was reached by the river on June 23rd but it dropped a foot following this period and the next freshet did not occur until the first week in July; during this week the river rose nearly four feet, reaching 20' on July 7th. It remained within a foot of this until a further rise carried it to 21' on July 18th.



17. TEMPERATURE CONDITIONS AT FLOOD SEASON.1919-21. original
Data from N.Nicomen; Supplied by Meteorological Branch.



18. FLOOD CONDITIONS 1919 - 21. Records at Mission Bridge.
Data from Dominion Department of Public Works original



19. FLOOD CONDITIONS DURING 3 WORST RECENT YEARS, 1911, 13 & 18 original
Recorded at Mission. Data from Department of Public Works.

The drop from this high level was fairly gradual and ten days later the river had only reached the 18' mark. It was thus over 18' 6" for a period of three weeks.(18' 6" is the level at which we estimate sufficient flooding occurs to give rise to a really serious pest). During most of this period the weather was much warmer than during the 1919 and 1921 freshets (the warmest day of the year occurred on July 8th when the temperature registered 91.5° F.) Larval development was very rapid as the warmth of the water and consequent decomposition of much flooded vegetation created an abundance of micro-organisms in the water - these are the main food of mosquito larvae and largely ~~responsible~~ regulate the rate of development. In the meadow mentioned under 1919 conditions flooding occurred on June 10th and great numbers of newly hatched larvae were noted on this date - the general emergence of adults from these was on June 21st, 11 days later. An extremely serious pest occurred this year as very extensive flooding took place and conditions were ideal for the rapid development of mosquito larvae.

1921 - Mosquito Conditions. During this year the river was exceptionally high reaching 21' 4" on June 12th. It remained about 18' 6" between June 4th and July 3rd (except for a slight temporary drop to 18' 3"). During this period the river dropped 3' within five days and many larvae were undoubtedly washed away. The weather during the period of high flood was moderately cold and larval development was somewhat slow. In the meadow mentioned under 1919 and 1920 eggs hatched on May 19th and the adult emergence occurred very early in June. (About June 6th)

Our field surveys indicated that vast numbers of larvae hatched out on the flooding of the breeding areas, and sod experiments showed considerably more eggs than in the Spring of 1920

In 1920 a sod (a little under 1 square foot) cut from the edge of Mission Prairie gave 654 fertile eggs. In 1921 a similiar area cut from the same place gave 3218 fertile eggs. No mosquito pest materialized however, and the district enjoyed an exceptional freedom from mosquitoes.

Our data was not sufficiently complete for us to be able to offer definite explanation for the failure of the mosquito pest to materialize in spite of the very extensive flooding that occurred and the fact that every indication pointed to an abnormally large mosquito crop. As a possible explanation we would suggest that as larval development was slow - on account of the fairly cold weather during and following the freshet - larvae may have been washed high on the peak of the flood and left stranded on the rapid drop of the river. Before development was completed the high pools containing the larvae probably dried out.

(b) Extent and Nature of Breeding Areas.

During the last two years of the investigations especial attention was directed towards a survey of the breeding areas. A motor boat used in 1920 made it possible to penetrate to the majority of the breeding places, and enabled us to make close observations of conditions in the field. In 1921 the Vancouver station of the Canadian Air Board co-operated with the Entomological Branch and areaerial surveys were made to give us data regarding the extent of the flood water breeding areas. (33) On May the 28th the river level was 17' 4" and W. H. Brown and C.J. Duncan made a photographic survey embracing the entire valley from Hope to Vancouver. The writer directed the taking of the photographs and obtained extensive notes on flood conditions vegetation, etc/ in the individual breeding places/

20. COTTON-WOOD FLOOD SWAMP BREEDING AEDES ALDRICHI
(Original) Mission Swamp.

21. FLOOD POOLS IN OPEN PRAIRIE BREEDING AEDES VEXANS
(Original) Sumas Prairie

22. SEMI-PERMANENT GROUND POOL BREEDING ANOPHELES AND CULEX TARSALIS (Original)

23. SEEPAGE FILLED RAILWAY DITCH BREEDING A.VEXANS CULEX TARSALIS AND ANOPHELES (Original)

24. PERMANENT SWAMP AREA BREEDING ANOPHELES AND CULEX TARSALIS
(Original)

25 PERMANENT POOL WITH COLD DEEP WATER.
No Mosquito breeding here.
(Original)

26. TYPICAL HABITAT OF AEDES MUTATUS Dyar.
Fraser Canyon (Original)

27. NICOMEN ISLAND JUST PRIOR TO BREAKING OF DYKE
Flood of 1921 (Original)

28. FLOODED ROAD AT EDGE OF SUMAS PRAIRIE
(Original)

29.SUMAS PRAIRIE UNDER FLOOD (Original)

30.CHILLIWACK VALLEY UNDER FLOOD.1894
Photo by G.W.Edwards. Vancouver.

31. MISSION DURING THE GREAT FLOOD OF 1894
Photo by G.W.Edwards, Vancouver,B.C.

32. FLOODS NEAR HATZIC 1894.
Photo by G.W.Edwards.

33. SMALL PUMPING STATION - NEWCOMEN ISLAND.
(Original)

On June 12th when the flood water was 21' 4" Messrs. McLeod and Duncan undertook a further aerial survey, and the writer obtained notes of great value indicating the encroachment of flood waters at this level. From these notes and aerial photographs we have been able to prepare a map indicating the position and extent of the main flood water breeding areas. The acreage is not easy to estimate owing to the evanescent nature of the flood water, which of course varies with each fluctuation of the river; but utilizing every source of information to which we have access the following is our estimate at a flood level of about 21 '.

Total flood water breeding areas 1921.	30,000 acres.
Areas affected by reclamation schemes at Sumas and Port Mann.	16,000 acres.
Total breeding areas remaining at completion of above dyking schemes.	14,000 acres.

Nature of Main Breeding Areas in the Lower Fraser Valley.

Cottonwood Flood Swamps. The flooded areas of the greatest importance are those clothed with dense vegetation, as the larval habitat of Aedes aldrichi Dyar is almost restricted to these cottonwood swamps. Aedes vexans and Aedes cinereus also breed here in numbers. There is a typical vegetation in these places - Cottonwood, Willow, Dogwood, Rose and Spireae growing with a jungle-like profusion. Below are listed the plants typical of the flora of the bottom land flood swamps * 36.

T R E E S:

Dominant.

Populus trichocarpa T & G	Cottonwood.
Salix lasiandra, Benth	Willow
Salix scouleriana Hook	Willow

* 36 List prepared by R. Glendenning, Agassiz, B.C.

Scattered.

Cornus stolonifera Michx	Swamp dogweed.
Alnus rubra Bong	Alder

Occasional.

Picea sitchensis Carr	Spruce
Abies grandis Linde	Balsam
Salix sitchensis Bong	Willow
Pyrus diversifolia Bong	Wild Crab
Salix hookeriana Barn	Willow

SHRUBS - Forming Thick Underbrush.

Rosa pisocarpa Gray	Wild Rose
Rosa nutkana	Wild Rose
Spiraea douglassi Hook	Spireae

HERBS - Covering the Ground in More Open Places.

Carex sitchensis Bong	Sedge
Carex festira Dewey	Sedge
Glyceria nervata Trin	Fowl Meadow Grass.
Alopecurus geniculatus L	Swamp Foxtail.

Flooded Meadows and Open Lands:

The other breeding areas of importance are the flooded meadows and open places. In these Aedes aldrichi does not occur to any extent but Aedes vexans Meigen finds the most satisfactory conditions for development. The table below indicates the proportion of different species in various flood water breeding places.

Proportion of Larvae of Aedes aldrichi and Aedes vexans.

Date	Nature of Area	Location	Aldrichi	Vexans	Other
17.VI.21	Cottonwood flood Swamp	Silverdale	167	37	6
do	do	do	121	44	4
do	Open meadow adjoining above.	do	11	216	0
15.VI.21	Cottonwood Area (Little underbrush)	Nicomen W.	44	20	0
13.VI.21	Small Willow covered area.	Sumas Prairie	18	59	0
13.VI.21	Open flooded area (at edge)	do	3	95	1
1.VI.21	Open flooded meadow	Mission	0	1593(?)	0

Ditches and other Promiscuous Collections of Water (Flood)

These usually contain considerable numbers of Aedes vexans larvae and some Culex tarsalis, Anopheles maculipennis and Anopheles punctipennis.

Permanent Swamps and Pools: Careful surveys showed that permanent bodies of water in the district are negligible, as the natural control ~~feeae~~ factors, predacious insects, etc., are efficient in keeping down mosquito breeding. On no occasions were larvae of Aldrichi or Vexans taken in these places but only moderate numbers of Culex tarsalis, Culex testaceus, Anopholes maculipennis and Anopholes punctipennis.

Woodland and Mountain Breeding Places:

The back country and mountain areas bounding the Fraser delta are thickly forested, mainly with coniferous trees such as Douglas Fir, Red Cedar, Hemlock and Spruce, with occasional deciduous trees as Broad Leaved Maple, Red Al- Alder, etc. The melting snow, especially in the mountain areas, causes the formation of temporary pools and a few species develop in these. Aedes punctor Kirby is the dominant form and Aedes aboriginis and Culiseta impatiens also breeds in these places. These species are very localized and seldom troublesome except at high altitudes. They are of very little economic importance in the district.

Data Regarding Main Flood Water Breeding Areas.

The map accompanying this report shows the extent of flooding at a river level of about 21' and indicates the approximate size and position of the more important flood water breeding areas in the valley. Many of these have been worked over in surveys for larvae, and considerable data have been obtained regarding them individually - this is given in the following pages. The numbers on the map correspond to the numbers in the description. To avoid misunderstanding, it may be as well to remark here that the acreages

given are merely rough approximations, but these are as accurate as the means at our disposal allowed.

(1) South Westminster (Surrey) East of Westminster Bridge to West limits of Port Mann. About 350 to 400 acres flood water at 21'/ No sign of flooding at 17'. Area thickly covered with rank growth of sedges, grass and spirea with here and there patches of willow. Aedes vexans larvae taken here in enormous numbers. 1921 emergence occurred June 23rd This area will very shortly be dyked.

(2) (a) Westminster East to Fraser Mills (Coquitlam). Wooded bottom land traversed by Brunnette River, extends between Fraser Mills lumber yards and Brunnett Mills, Westminster. Flooded area about 250 acres. No flooding at 17' occurred. Typical Cottonwood flood swamp with many acres of open nature. Aedes vexans adults only species taken in vicinity (on June 25th, 1921).

(2) (b) Coquitlam (Coquitlam) The flooded area extends from below C.P.R. junction along the Coquitlam River to the mouth, and from here West to Fraser Mills. About 550 acres are involved/ At 17' fairly extensive flooding occurred at one mile West of Coquitlam River. The greater part of this area is typical Cottonwood flood swamp, but here and there are small stretches of open area. Larval surveys have shown Aedes aldrichi and Aedes vexans larvae in considerable numbers. Fairly extensive oiling operations have been attempted in this district and a certain amount of dyking has been accomplished.

(3) Douglas Island (Unorganised) This area comprises some 400 acres. At 17' the West point only is flooded, but at 21' flooding is very extensive especially in the centre. The centre of the island is more or less open with much spirea and sedge and somewhat scattered willow; but around the outer edges there is a fairly heavy covering of Cottonwood, etc. except at the West point.

Our surveys indicated a peculiar condition here, for we found Aedes cinereus to accur in greater numbers than anywhere else in the valley. This species was fully 80 % dominant but, Aedes vexans and Aedes aldrichi also occurred in considerable numbers.

(4) Kanaka Creek Area, between Haney and Albion (Maple Ridge) The flooded area is situated in the centre half between Haney and Albion, immediatly East of the big lumber bridge and adjacent to Kanaka Creek. Some 75 or more acres are involved at a high flood level, but at 17' practically no flooding occurs. The area is covered with thick vegetation and is typical cottonwood swamp. Aedes aldrichi is the dominant form breeding here, but Aedes vexans also breeds in limited numbers.

(5) Fort Langley Salmon river area (Langley). Floods extend East and West along Salmon River in semi-circular strip about the length and breadth of McMillan Island. At 17' fairly extensive flooding occurs, and nearly 1,000 acres are involved at a level of 21'. The greater part of this area is open but some patches of typical Cottonwood swamp occur. We have no larvae from this breeding area, but Aedes vexans is probably the main form. Mosquitoes are a terrible curse in this vicinity in some seasons. There has been a great deal of agigation for the reclamation of this area, but up to the present nothing material has been accomplished.

(6) McMillan Island (Langley) This Indian Reserve shows little flooding at 17' and is only affected by very high water. The water is then in shallow pools and provides ideal conditions for mosquito development. We would estimate that the mosquito breeding area on this Island would be about 500 acres. The greater part of this is unimproved Cottonwood swamp and although we have no ~~complete~~, samples, Aedes aldrichi is almost certain to be the dominant species. From the reports of Indians and others the pest would appear tobe extremely serious here.

(7) Beaver Creek Area (Langley and Matsqui)

Since the completion of the dyke about 60 acres is all that remains of the very extensive flood water breeding areas that used to occur in the Glen Valley. The area is open and lies adjacent to the mouth of the Beaver Creek. It was largely flooded at 17'. We have no specimens of the mosquitoes occurring here, but they would probably mainly be Aedes vexans.

(8) Mouth of Whonnock Creek (Maple Ridge) A small Cottonwood swamp occurs in the Indian Reserve by the mouth of Whonnock Creek - this lies opposite the West point of Crescent Island and near old church. Only about 17 to 20 acres are involved at a 21' level. Cottonwood swamp is capable of producing considerable numbers of Aedes aldrichi. We have no larval samples from this breeding area.

(9) Ruskin Flats (Mission) An extensive flood area at the mouth of the Stave river. About 300 acres flooded water at 21'. Even at 17' total flooding occurred. The area is almost entirely open meadow through which runs a number of shallow winding sloughs. There is little vegetation except low sedges and grasses. During the last three years surveys have been made for larvae, and sod experiments have been carried out to determine the presence of eggs. We have been been unable to incriminate this area and have never taken any larvae here. It is not easy to account for this, but the depth and coldness of the flood water and the cold breezes that blow across this area (caused by the proximity of the Stave Canyon) may in part be responsible.

(10) Silverdale Area (Mission) Silverdale School house lies opposite to the flood area, and the mouth of Silver Creek lies towards the East end. About 400 acres of flood water breeding places occur at a 21' river level. At 17' flooding occurs only at the mouth of Silver Creek and at a point opposite the School House. Part of this area is open, but a very great deal of it is typical Cottonwood swamp. Conditions are ideal for the production of large numbers of Aedes aldrichi and Aedes vexans and in our surveys we have found the larvae of both species to occur here in very great abundance.

(11) Mission Cottonwood Swamp and Flats (Mission)

The flood water extends from within the town to where the Wren road ends at the river; and embraces the area locally known as New Seattle. The area is traversed by a small stream and a number of sloughs. The flood water at 21' embraces some 250 to 300 acres, some of which is actually within the limits of the town. At 17' only slight flooding occurs. A portion of this area is in the nature of open flats and meadows, suitable for producing Aedes vexans only, but the greater part of it is a typical cottonwood swamp/ Sod experiment and larval surveys show this to be a very important breeding place for Aedes aldrichi and Aedes vexans - a single square foot of sod from the Flats gave us over 3000 larvae.

(12) Matsqui Islands(Indian Reserve)

About 350 acres of breeding area are involved in these Islands; At 21' the islands are almost totally submerged, but at 17' only a few of the lowest places are flooded. Most of this area is typical unimproved cottonwood swamp. Our surveys show that Aedes aldrichi and Aedes vexans breed here in enormous numbers.

(13) Matsqui Prairie (Matsqui) Since effective dykes have been completed contains only about 125 acres of breeding areas.

(A) Matsqui Main Indian Reserve. Lies at the mouth of Nicholson Creek East of Mount Lehman and north-east of Gifford. A considerable acreage of flooding water occurs here at 21' but practically none at 17'. The area is almost entirely unimproved Cottonwood swamp, ideal for the production of Aedes aldrichi. While we have no larval samples there is no doubt that Aedes aldrichi and Aedes vexans breed here in great numbers.

(B) A strip of land of varying width runs outside the Matsqui dyke. The widest part is opposite Hatzic and a fairly wide strip extends here to the base of Sumas Mountain. Considerable flooding occurs at 17' and at 21' flooding is general. The area is typical Cottonwood swamp. Our surveys show that Aedes aldrichi breeds here in great numbers, a small proportion of Aedes vexans also occurs.

(C) Small shallow areas of seepage occur inside the dyke here and there - mainly just opposite Mission and just East of the Mission Bridge. No collections were made here, at the time larvae would be present, but similar places elsewhere give numbers of Aedes vexans and Culex tarsalis.

(14) Hatzic-Dewdney (Mission * onorganised)

This area extends from Hatzic landing to the junction of Nicomen Slough (West) with the Fraser (near the new boat landing). The total flood area at 21' is from 500 to 600 acres. The area south of the C.P.R. and bounded by Hatzic Creek is very extensively flooded at 17'; and at this level, a small amount of flooding occurs in the area to the East. At high river levels almost total flooding occurs around the edge of the latter area and there is also much encroachment of flood water towards the centre.

The greater part of this breeding place is typical Cottonwood swamp and our larval surveys show that enormous numbers of Aedes aldrichi are produced. Aedes vexans also breeds there but to a lesser extent. There has been much discussion of a dyke from Hatzic extending round the Nicomen Island as far as the highland in the East, but there seems little hope of this being undertaken for some years. At the present time a small dyke exists where the C.P.R. crosses the Hatzic River and a pump here prevents flooding on Hatzic Prairie and Hatzic Island.

(15) Murphey's Landing (Unorganised - Sumas Mountain)

A small breeding area lies at the base of Sumas Mountain, East of Murphey's Landing and opposite the west mouth of Nicomen Slough (by the stretch of the Fraser known as Devil's Run.) The flood water area comprises some 15 - 25 acres at 21'. The area is dense Cottonwood swamp and a small slough traverses it. We have not larval samples but authorative reports have been given us to the effect that the water is teeming with larvae at early flood. Adult surveys, made later in the season, showed a great number of mosquitoes; nearly all Aedes aldrichi.

(16) Nicomen Island, West (Unorganised)

This area (about 5,000 acres in extent) is dyked and extensively cleared and developed. The dyke is however ineffective and has broken under the high water of the last two years. The resulting flood water breeding areas must aggregate over 1,600 acres at 21'. Although a great deal of the flooding is on cleared open land, there are extensive Cottonwood swamps especially along the South edge (in a strip opposite Sandy Island), opposite the Nicomen gravel quarry, and at the Southeast edge. Extensive larval and adult surveys have shown very great numbers of mosquitoes to be produced. Aedes aldrichi is dominant, but Aedes vexans also breeds abundantly.

There has been a great deal of agitation for the efficient dyking of Nicomen Island, and the question is being constantly brought before the B.C. Legislature. If a satisfactory agreement can be arrived at between the Dominion and Provincial Governments, it would appear that an efficient dyking and pumping system can be inaugurated within a few years.

(17) Nicomen Island, East (Unorganised)

This is undyked and mainly unimproved Cottonwood swamp. The main Island, bounded on the West by Quaanitch slough and on the East by Zuttscallachan slough is about one third cleared, but the South-east portions are undeveloped. East of this lies Trumbley's Island; the island comprising Skumalasph Indian Reserve, and Queens Island. At 21' extensive flooding occurs on all save Trumbley's Island and a number of high ridges on the main island. Flooding is worse towards the East ends of the islands, and a total of about 1,600 acres is affected. At 17' only the extreme East ends of the Islands are flooded. All save Trumbley's are dense undeveloped Cottonwood swamp. Our surveys show East Nicomen to be one of the worst breeding areas for Aedes aldrichi in the Valley.

(18) Mainland North of Nicomen Island (Unorganised)

A strip of flood land lies South of the C.P.R. track at the mouth of Suicide Creek. Considerable flooding occurs at 17', and at 21' the area is almost totally flooded save for a few small cleared areas. There are some 350 acres involved. All save the cleared portion is typical Cottonwood swamp. We have no larval sample but conditions are ideal for Aedes aldrichi and adult surveys indicate that this species breeds here in great numbers.

(19) A triangular area of land occurs south of the C.P.R. track, extending from Nicomen gravel quarry to Deroche and in a strip East of Deroche for about 3/4 of a mile.

Considerable flooding occurs at 17' and at 21'. Some 260 acres are involved. A great deal of this area is Cottonwood swamp and Aedes aldrichi larvae probably occur here in great numbers. We have no larval collection from this area but surveys showed adults to be extremely abundant.

(20) Sumas Prairie S.W. (Sumas)

This low-lying area to the South West of Sumas Lake is liable to flood to more than 9,000 acres when the river level reaches 21'. Fairly extensive flooding occurs at 17'. While most of the land is in the nature of open prairie, there are large acreages with a covering of Willow, Spireae, etc. The water, is , in the main, shallow and warms quickly; and consequently is rich in the minute life upon which mosquito larvae feed. Our larval surveys have shown enormous numbers of Aedes vexans at the edges of the flood. Aedes aldrichi also occurred and were abundant wherever there was cover of cottonwood and willow. Since the above was written this area has been reclaimed by the Sumas Dyking Scheme.

(21) Sumas Prairie N.E.(Chilliwack)

This is divided from the last area by the Sumas Lake and extends East from the mouth of Sumas River and North to the Fraser from the Lake. At a 21' level some 7,500 acres of flood water occur. About 1/7th of this is affected at a 17' level. An extensive network of sloughs wind through the area, a large proportion of which is typical Cottonwood swamp (unlike the South West prairie). Our larval surveys show that Aedes aldrich breed here somewhat more abundantly than Aedes vexans, although the latter occur in vast numbers. All save 700 or 800 acres in the North West corner has been reclaimed by the Sumas Dyke since the above was written. This area is dense cottonwood swamp and was a very important breeding place for Aedes aldrichi.

(22) Chilliwack Cottonwood Flood Swamp (Chilliwack)

This area lies South East of Chilliwack Mountain, East to dyke D.(protecting the town from the West). At a height of 21' some 1,000 acres are affected by flooding and even at 17' a considerable amount of flooding occurs. The area is almost entirely dense Cottonwood swamp in which the Chilliwack river, the Atchalitch and the Luckackuck meet in a network of sloughs. Our larval surveys show both Aedes aldrichi and Aedes vexans to breed here in vast numbers. Nothing in the nature of dyking has been considered here. A portion of the area is Indian Reserve.

(23) Skway Indian Reserve (Chilliwack)

This Island lies immediately West of the town of Chilliwack. At 21' it is almost entirely flooded and must contain some 400 to 500 acres of breeding area. At 17' about half of it is covered ~~ith~~ with water. The Island is unimproved Cottonwood swamp and is well adapted for the production of large numbers of Aedes aldrichi. We have no larval samples.

(24) Area Lying North East of Skway Island and Chilliwack, Fairfield,- Windermere,- Dykes to Greyell Slough(Chilliwack)

At 21' this area contains very extensive flood pools. The area involved amounts to some 1,500 acres. At 17' very little flooding occurs. The entire area is covered with a thick growth of Cottonwood, etc. and constitutes a breeding area of some importance for Aedes aldrichi. We have no larval collections from this area.

(25) Islands North of Windermere Islands and Divided from these by the Greyell Slough (Chilliwack).

Some of these islands are little more than sand bars, while others are fairly high out of the water and suffer little flooding. All are covered with a thick growth of Cottonwood, Willow, etc. At 21' extensive flood pools occur and the breeding areas must aggregate about 300 acres.

At 17' there is very little flooding. We have no collections from this place but it is excellently adapted for Aedes aldrichi.

(26) Harrison Mills District (Kent and Scowlitz Indian Reserve)

This area lies at the West point of the municipality of Kent. A slough runs in a south-easterly direction from the neck of Harrison Bay towards the Fraser River, and water backing up this slough causes a large acreage to become flooded. The town of Harrison Mills and surrounding areas are badly flooded, and extensive flooding occurs in the Indian Reserve in the South portion. The area under water at 21' comprises about half of the area lying West of the high land that extends North and South in a line with the East boundary of the Indian Reserve. The breeding areas involve some 500 acres. The greater part of this is cleared, but fairly extensive cottonwood flood-swamps occur and observations of adult specimens indicate that great numbers of Aedes aldrichi are produced, as well as Aedes vexans.

(27) Islands Mouth of Harrison River (Kent, Unorganised)

Opposite the mouth of Harrison River is a group of islands of varying sizes, and extending West of these are three small islands at the East limits of Nicomen slough. At 21' the majority become completely flooded and the resulting breeding areas must aggregate some 150 acres. Little flooding occurs at 17' except in the three Westward Islands. All the Islands are thickly covered with typical Cottonwood swamp vegetation, and should provide good breeding conditions for Aedes aldrichi. We have no larvae or adults from them.

(28) Island South West of Agassiz (Kent)

At the mouth of the Agassiz slough and divided from the mainland by the Cheam slough is an island of some 300 acres, that is extensively flooded at 21'. There is also a large flood area on the mainland opposite and the total acreage of breeding area must be some 400 acres.

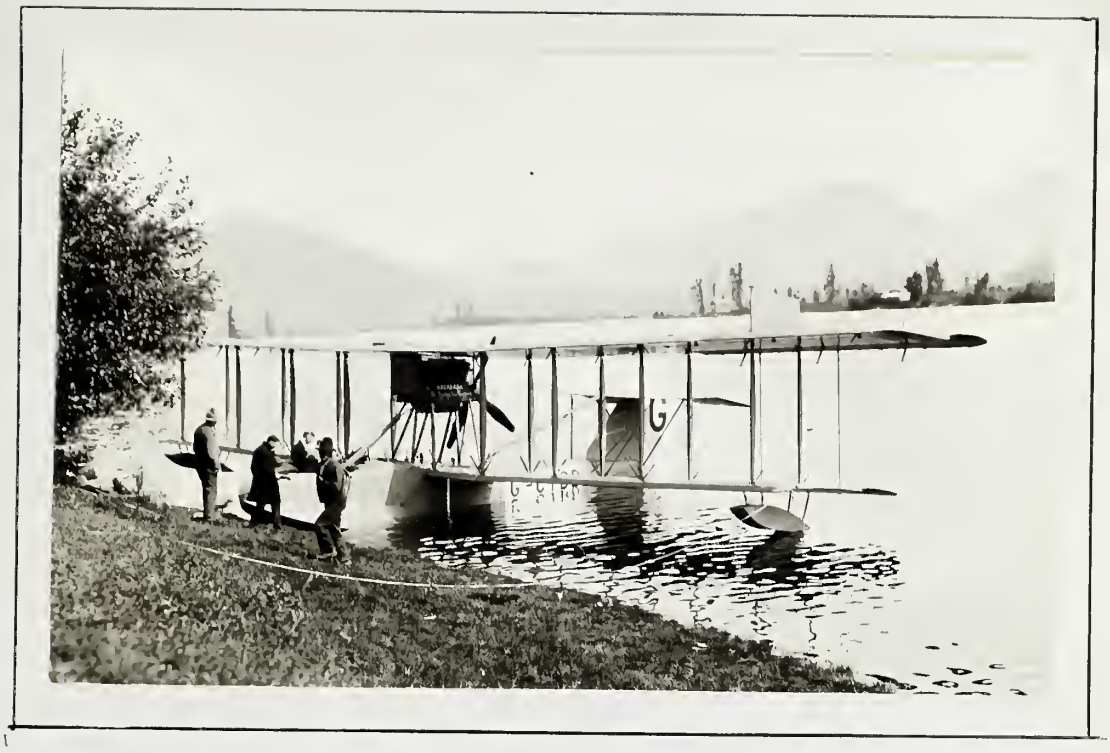
All of this is typical Cottonwood flood swamp and from observations of adult specimens produces a very great number of Aedes aldrichi. No larval collections have been made.

(29) Sea Bird Island (Indian Reserve)

About 7/8th of this area is unimproved Cottonwood bottom land but the elevation is sufficiently high to prevent many flood pools forming even at 21'. At 17' practically no flooding was noticed.

(30) Cheam Lake to Hope (Unorganised)

The topography of this area - which is very mountainous does not render it conducive to much settlement. The district is not of very great agricultural importance, although there are one or two excellent flat areas that are fairly well developed. In the Laidlaw district for instance, there are about 1,000 acres of arable land. Mosquitoes are at times troublesome in these sections. There are a number of small breeding places - some of these being islands subject to floods, and others low places on the mainland. There is not much flooding at 17', but at 21' considerable acreages of flood pools occur on the group of islands opposite the west end of the Sea Bird Island and on the islands opposite the mouth of the Maria slough. In the Laidlaw district the cottonwood swamp in the vicinity of Jones' Creek breeds large numbers of Aedes aldrichi and there are several others extensive stretches of flood water - some in cleared areas and others in the undeveloped portion. A bad breeding area occurs in the Cottonwood swamp at the mouth of the Silver River, just West of Hope, and lumbering interests here are somewhat affected. Although no larval collection have been made in this section; surveys for adults gave numbers of mosquitoes, mainly Aedes aldrichi, but also a proportion of Aedes vexans and in a few places Aedes punctor and Aedes aloponotum. Cheam Postoffice, Laidlaw, and Silver River, were the worst places for the two



34. AIR BOARD SEAPLANE AT HATZIC LAKE
Undertaking mosquito survey (original)

35. AERIAL PHOTO OF PART OF SUMAS PRAIRIE
Showing big dyke under construction, 1921
Photo by Duncan, Air Board. (Original)

36. AERIAL PHOTO OF EAST END OF NICOMEN ISLAND.
Flood encroachment at 17'6"
Photo by Duncan, Air Board, Vancouver, (Original)

37. NEAR VIEW OF ABOVE SHOWING DENSITY OF VEGETATION
Photo by Duncan, Air Board Vancouver, (Original)

38. AERIAL PHOTO. FORT LANGLEY - Floods at 17'6"
Photo by Duncan, Air Board, Vancouver.
(Original)

39. AERIAL PHOTO - Nicomen Islds in floods of 1921
Photo by Duncan, Air Board, Vancouver.
(Original)

NICOMEN ISLAND-Floods at 21' level; 12.vi.1921
Photo by Duncan, Air Board.
(Original)

40.

41.

42.

43.-MAP SHOWING POSITION AND SIZE OF MAIN FLOOD WATER BREEDING AREAS. AT RIVER LEVEL OF ABOUT 21 FEET.
COMPILED FROM AERIAL PHOTOS & OBSERVATIONS. (Original)

former, and the woods in Popgum gave great numbers of the two last named species.

II. Natural Control Factors:

While the scope of our investigation did not extend to a detailed study of the various natural factors controlling mosquitoes, incidental observations indicated that considerable numbers of mosquitoes were destroyed by predaceous insects and other natural enemies.

(a) Enemies and other Natural Control Factors affecting Mosquito Larvae:

Drying of Breeding Pools. On a number of occasions where the water level dropped fairly soon after a flood had occurred it was found that many pools dried up sufficiently quickly to cause the death of large numbers of wrigglers. Mosquito larvae were found to be capable of living some days on the surface of the mud that remained moist but none survived a complete dessication of twenty four hours. Pupae appeared somewhat less susceptible to drying, and emergence of adults was noted from pupae lying on the surface of partially dried mud. A condition causing quick evaporation of water in the breeding areas after a rapid drop of the flood level is undoubtedly one of the most important natural control factors affecting flood pool mosquito larvae.

Insect Predators: During field observations great destruction of mosquito larvae by insect predators was often noted. Most permanent bodies of water contained considerable numbers of enemies that preyed on wrigglers - enough were found to be present in most cases to prevent any appreciable mosquito breeding. Even in temporary bodies of water considerable killing was evident. The larvae of Dytiscid beetles popularly known as water tigers, appeared to be the most efficeint insect enemies of larvae ~~wit~~ and were frequently observed attacking mosquito larvae with great voracity - They are fairly abundant in the district.

The larvae of various species of Hydrophylid beetles or water scavengers were also noted feeding extensively on mosquito larvae. Dragon fly larvae (various Anisoptera) were found to be fairly abundant, but although they will attack mosquito larvae their bottom feeding habits limit their value. Back swimmers (Notonectidae) were found to be very common and to kill large numbers of larvae and pupae. We were unable to incriminate water boatmen (Corixidae). Eucorethra underwoodii larvae were found ~~to~~ in many places and mosquito wrigglers were fed upon by them.

Water Mites: A small dark red mite, found in cottonwood swamps, was noted feeding avidly on mosquito larvae. The mites were extremely active and voracious and mosquito wrigglers appeared to be their main food. Several mites brought back in a jar with a number of large Aedes vexans larvae were found to have killed all by the following day. These mites have unfortunately not yet been identified, but in 1921 a little was found out regarding their life history. Three specimens, kept for several weeks in a jar, well supplied with wrigglers, laid a number of eggs on dead leaves and twigs on the bottom of the container. Each mite laid several hundred eggs - these were bright scarlet, spherical, and were laid in clusters of considerable numbers. The majority of eggs remained unhatched during the time they were under our observation, but a few hatched into minute mites, which differed in colour from the adults, being bright scarlet ~~instead~~ instead of deep wine red. The presence of these small mites in numbers shortly after the flooding of the cottonwood swamps would indicate that the winter is passed in the egg stage - the eggs being laid the previous season on dead leaves and debris in the flood water. We have never seen this mite in permanent bodies of water.

Fish: Young trout fry were found to be fairly abundant, and these and the fry of other fish were noted on several occasions destroying great numbers of mosquito larvae. Large shoals of fry were sometimes seen following each other in constant succession around the edges of flood water, wherever it was sufficiently deep and free from much vegetation. They cleaned up the mosquito wrigglers very effectively where they could reach them. Two spined sticklebacks were found in many places, but their value appears somewhat problematical.

Shore Birds: Observations of various shore birds at the edge of the flood waters on Sumas Prairie indicated that they were devouring great numbers of mosquito wrigglers, but no examinations of stomach contents were made. In New Jersey the examination of stomachs of one species of shore bird - Northern phalarope - showed that 53% of the food consisted of mosquito larvae and a number of other birds were found to feed on larvae. Several hundred larvae were found in the stomach of a Killdeer.

Salamanders: These amphibians - locally known as mud puppies - are frequently encountered in the district in swampy places. We tried some feeding experiments with them but all resulted negatively. Chandler (34), however, in Oregon found that the western Newt (Notophalmus torosus) was a very effective natural enemy of mosquito larvae; and in feeding experiments as many as 208 mosquito larvae were eaten in 24 hours. Salamanders placed in water barrels containing many hundred larvae succeeded in killing all before any pupation took place. The common Fraser Valley Salamander is the same species as that occurring in Oregon.

The Value of the Enemies of Mosquito Larvae:

In permanent bodies of water natural enemies undoubtedly keep mosquito breeding very effectually checked, but in temporary flood pools mosquito wrigglers appear to have the advantage over their enemies. Very great numbers of wrigglers are killed but the natural enemies do not become established fast enough in the flood pools to make much headway against the enormous numbers of more rapidly developing mosquitoes.

Experiments showing Voracity of Predators:

A few experiments were undertaken with a view to a comparison of the various predators. As these were conducted under very artificail conditions they cannot be taken as a guide to the actual value of the insects involved. They are, however very suggestive when considered in conjunction with the field observations and indicate the extraordinary voracity of some of the mosquito enemies. In the experiments tabled below Aedes vexans larvae were used - these were approximately the same size e.g. 1/4" (4 days old). The wrigglers were placed in a dish with a single specimen of the predator. The asterisk marks the termination of each experiment.

Predator	LARVAE KILLED.					Total larvae supplied.
	1 hr.	8 hrs.	19 hrs.	34 hrs.	48 hrs.	
Dytiscid Beetle larvae 1 3/4"	89	200	-	399	488*	500
Dytiscid Beetle adult 3/4"	0	0	-	0	0	100
Dragon Fly Larvae 1 1/4"	88	-	192*	-	-	200
do do 2"			195*	-	-	200
Back Swimmer (notonectidae)	3	94	-	100*	-	100
Water Boatman (Corixidae)	0	0	4	4*	-	100
Small Fish (Stickleback)	100	-	195*		-	200
do	(Fish died at 48 hours)				877*	1553

(b) Enemies and Other Natural Control Factors Affecting Adult Mosquitoes:

Freezing Temperatures:

It is generally considered that many adult Aedes are usually killed by early frosts, and to test this some experiments were conducted at the Hatzic Cold Storage plant.

A number of Aedes aldrichi were taken biting near the laboratory on July 12th, 1921. Ten of these were placed in a large cheesecloth cage in the cold storage plant and ten were placed in a similar cage on the laboratory verandah, for a check.

Date	Time	Temp.	Remarks.
12-7-21	10 a.m.	42°F.	Specimens placed in Cold Storage plant.
13-7-21	10 a.m.	42°F.	All alive and active after 1/2 hour sun bath.
14-7-21	3.15 p.m.	42°F.	All alive and active after 1/2 hour sun bath.
15-7-21	3.15 p.m.	32°F.	9 dead and 1 very feeble. Temperature dropped slightly below 32°F during night. Freezing for over 12 hours.

Check: Check specimens alive and active July 15th at 3.15 p.m. but all died within eight or nine days. The temperature recorded at the nearest weather station - North Nicomen - between July 12th and July 24th did not exceed 82 or go lower than 46.

Conclusions: Adult female Aedes aldrichi can stand a temperature of from 40°F to 42°F for several days without showing ill-effects, but are soon killed at a temperature below 32°F.

Parasitic Worms: In 1920 and 1921 numbers of Aedes vexans were found to be affected by a nematode parasite which has proved to be a new species and has been named Parameris canadensis by Dr. Steiner (35) of the U.S. Bureau of Plant Industries.

In mosquito samples examined in 1920 as many as 80 % contained parasites - In 1921 the parasitism in those examined was about 20%. The effect of the nematode appears to be to check the development of the ovaries, as in no specimens in which parasites occurred were the eggs well developed. The largest worm found measured 1 1/4 inches and there were from one to six in a mosquito. Aedes vexans was the only species much affected; a single specimen only being found in Aedes aldrichi, in this case there was no effect on the egg development/ There can be little doubt that the parasite must considerably check the numbers of Aedes vexans.

Birds and Bats: A number of birds found in the Valley are known to feed extensively on adult mosquitoes. While we have made no examination of stomach contents, field observations indicated that mosquitoes were being eaten by several species. Six hundred mosquitoes have been taken from the stomach of a single nighthawk; and members of the goatsucker or nighthawk family, and bats are probably the most effective enemies of adult mosquitoes as their time of flight coincides with the time most mosquitoes are on the wing. Swifts and Swallows also without doubt destroy large numbers. These latter however , - and dragon flies - feed at the wrong time of day to be really effective. They do not usually fly in the shaded places ~~sought~~ in which mosquitoes shelter in by day.

Parasitic Mites:

A small red mite is sometimes found attached to adult mosquitoes and , if abundant, might have some adverse effect, although this is somewhat problematical. In the Fraser Valley however, we have not found them to be numerous.

III. ARTIFICIAL CONTROL MEASURES:

(a) Permanent Control - Dyking and Pumping.

Wherever it is in any way possible, the elimination of flood water breeding areas by dyking and pumping is in the long run the most economical and satisfactory method of dealing with the pest. This can usually, however, only be attempted when the dyking project is able to pay for itself by the actual value of the land reclaimed. The bottom lands of the Lower Fraser valley are of excellent quality, and where the amount of dyking necessary is not excessive in proportion to the area of land reclaimed, the financial outlay should give good returns. Very large areas have already been reclaimed. Successful dyking projects embracing many thousand acres have been undertaken at Pitt Meadows, Barnston Island, Glen Valley, Matsqui Prairie, etc. A large dyke prevents flood water from covering very extensive areas in the Chilliwack valley. The Sumas reclamation project is now completed (1923) and it is believed that comparatively few mosquitoes will be produced in what was one of the most prolific breeding areas in the valley. The most westerly breeding area of any size - that west of Port Mann - will shortly be dyked. Nicomen Islands - especially East Nicomen - are now among the greatest obstacle in the way of mosquito control. Some dyking has been attempted here but this is ineffective and the dykes have given way on many occasions - as in 1920 and 1921. Agitation for effective dyking has been intense for some time, and it has been suggested that a dyke should be built from Hatzic, East around the islands to the higher mainland East of Queens Island. The writer is in no way qualified to state whether this scheme would be feasible or financially sound, but from a mosquito control viewpoint effective dyking and pumping of the area would be of the utmost value to the district, as the Nicomen Islands are the most extensive breeding areas remaining in the Valley.

Another breeding area that appears to offer some possibilities for dyking is that at Fort Langley - about 1,000 acres are affected at very high floods and there has been much agitation for reclamation. The feasability and individual merits of each dyking problem in the district belong to the problems of ~~are in the field~~ of the reclamation engineer and we are not in a position to discuss them here; we are, however, emphatically of the opinion that efficient protection from the mosquito pest can best be realized by the reclamation of flood water breeding areas wherever this can be undertaken. The majority of bottom lands are of only slight value until reclaimed, but with efficient dyking and pumping they become of the greatest value for agricultural purposes on account of the depth and richness of the alluvial soil. The great increase in value is of course a very important factor in favour of reclamation. In some narrow strips of flood areas where dyking would not be economical, filling by means of suction dredges could probably be undertaken with satisfactory results.

(b) Temporary Control Measures, Larvicides, Oils and Oiling Methods.

Pending the time when reclamation work can be undertaken and in places where such work is not feasable, temporary measures of control must be resorted to. That is to say, the application of substances causing death to mosquito larvae must be made on the breeding areas following each flooding. For many years the ideal substance for killing mosquito larvae has been keenly sought after in many parts of the world, and experiments are constantly being made to discover a cheap and really efficient larvicide. Headlee (36) gives the following as the ideal.

"It shall destroy quickly all mosquito larvae with which it comes into contact, should be non-poisonous to man and the higher animals, should be non-injurious to water plants, should remain effective in the pool throughout the season even when it becomes dry and refills many times, and should be cheap enough to render its use practicable under ordinary mosquito control conditions". No substance yet found has filled these specifications, although a very great number have been tested. Among these are the following:- Sulphuric Acid, Permangenate of Potash, Chlorine, Copper And Iron Sulphate, Nicotine, Lime, Salt, Quassia, Pyridine, Cresol, Lysol. Phenol, Arsenical powders as Paris Green, etc. Phinatas Oil, Paraformaldehyde, Nitre Cake, Panama Canal Zone Larvacide and various petroleum oils. In most mosquito work the latter three are the only substances that appear to warrant serious consideration and under New Jersey conditions. Headlee (37) gives the following recommendations for the specific purposes for which they are best fitted.

> "Nitre Cake - Fire Barrels, Tubs, and in some cases permanent pools.
>
> Canal Zone - Shallow temporary pools where killing must be quick, flooded cellars where wall staining is a serious consideration, pools in which the irritating mosquito (Mansonia perturbans) is breeding.
>
> Mosquito Oil - all other surfaces which cannot be reached by drainage, filling or fish".

Mosquito workers in general are agreed that taken all round petroleum oils remain the most satisfactory substances for killing mosquito larvae, as they cover a far wider range of conditions than anything else so far tested. For control work in British Columbia, oil is certainly to be recommended in preference to other substances. However, as the Canal Zone larvacide is useful in some specific circumstances, brief directions for making it are given below. In scouting for larvae it is helpful to carry a small quantity of this larvacide, as a little in a pool will cause all wrigglers to leave cover and come to the surface with much movement

Canal Zone Larvacide: 150 gallons of carbolic acid (minimum of 15% phenol contents; Sp. Gr. 0.97) are heated in a steel tank to 212°F. 150 pounds of finely powdered resin are then added - the temperature is kept uniform and the mixture constantly stirred. Thirty pounds of caustic soda dissolved in a gallon of water are added and the heating and stirring are continued until the mixture emulsifies completely. It is stated that Anopheles larvae will die within half an hour where this larvacide is used at the rate of 1 part to 10,000 parts of water. When this larvacide was first developed the cost in Panama was about 14¢ (per gallon) but in 1922 was about 62¢ (38). In Canada the cost would be nearly double this. This prohibitive cost renders the use of this larvacide out of the question except for a few specific purposes.

Petroleum Oils and Oiling Methods: As mentioned above petroleum oils have been found to be the most effective substances for killing mosquito larvae; and are to be recommended as superior to various chemicals and proprietary larvacides so far as discovered.

Causes of Lethal Action of Petroleum Oils: A number of theories have been advanced to account for the lethal action of oil - Ross in 1911 suggested that the oil layer annulled surface tension and that larvae were unable to hold themselve at the surface long enough to breathe. Another very widely held theory was that the oil film acted as a barrier between the larvae and the air and that this led to suffocation It has also been suggested that death was caused by a toxic p~~ortion~~ Constituent of the oil being soluble in water. Experimental evidence however indicates that none of the above theories explain the killing. Freeborn and Attsatt of California (39) carried out a valuable series of experiments in 1918 and proved that the oil vapours are the main toxic factors in most petroleum oils. Their conclusions are that the volatile

constituents of petroleum oils contain the principles that produce the primary lethal effect. Toxicity increases with volatility and the lethal effects are due to the penetration of the tracheal tissue by the volatile gases. In heavy oils (with boiling point above 250°C) it was found that volatile action was secondary to the effects of contact of oil with body tissue and with mechanical plugging of the trachea.

Grades and Mixtures of Oils Recommended.

Almost any petruleum oil that flows well, is cheap, and does not disappear too quickly, may be useful in killing mosquito larvae. Kerosene has in the past been very extensively used but there are other oils far superior. Headlee(40) states that the best oil for mosquito control is "one that forms a complete homogenus flim when applied to the water surface by a small portable sprayer, and which remains effective for at least two weeks, or better still for one month". Quayle in California recommends a combination of the following:- Heavy Oils of 18° gravity, four parts to one part of light oil of 34° gravity. Oils of from 26° to 34° gravity appear to be usually most satisfactory. The writer recently tested some twenty samples of oil sent by various Canadian companies. These were chosen by the companies as appearing especially well adapted for mosquito control work. In the tests made attention was paid; First - to the lethal action i.e. rapidity of killing and the duration of killing power; Secondly - to the filming power - i.e. the rapidity of spread, longevity and visibility of the film, and the absence of a tendency to adhere to vegetation. Some oils that showed good promise from their physical aspects gave only 50% killing in 72 hours. Others giving an excellent iridescent film, only accomplished 28% killing in 24 hours. One petroleum oil however stood out as decidedly superior to all others - this was a product of the Imperial Oil Company and was designated Imperial Mosquito Oil #105.

Below is given a table comparing this with the four other oils that came nearest it in the tests.

Sample & Company	Percentage of Mortality. 6 hr	24hr.	72 hr.	5 day film (48 hours)	Film.
Imperial #105	58	72	100	80	Spreads rapidly forming even lasting film. No tendency to cling to vegetation.
Imperial Star Fuel Oil	58	60	100	50	Spreads slowly. Tends to remain in globules. Sticks to vegetation.
Imperial Saw Oil.	50	56	100	40	Poor at start but giving good even film later. Sticks to vegetation.
Imperial # 104.	26	62	96	20	Spreads fairly rapidly giving fair good film.
Kerosene (Imperial)	24	50	100	0	Spreads rapidly but not so well as 105. Gives good film but has poor visibility. Loses toxicity fairly rapidly.

The above tests were made with oil at a rate of 1 ounce per 15 square feet. Fifty full grown Aedes lazarensis larvae were used for each sample. Under the heading (5 day film 48 hours) the film was left untouched for five days and fresh larvae were transferred by pipette to each dish. At the end of 48 hours counts were made to ascertain the mortality.

We would recommend # 105 as the best oil we have yet tested - the price is about 25¢ per gallon.

Note:

Where treatment is needed on pasture lands or areas where hay is to be cut shortly, a fast evaporating oil as gasoline should be used, as this will disappear in a short time without leaving any objectionable residue or odour. Several applieations may be needed.

Methods of Applying Oil: One of the simplest methods of applying oil and the one most generally employed is by means of an ordinary watering can with a rose nozzle. A knapsack sprayer is often useful and oil may be applied as a fine spray on the surface; or a straight jet may be directed under the surface; if the force is good and the oil will spread well on rising and will form a good film. Large expanses of water with sufficient depth can best be oiled by means of a barrel pump mounted on a raft or boat. The quantity of oil recommended for efficient killing is about one ounce per 15 square feet. Where there is much floating debris or fairly dense vegetation, sawdust soaked in oil may be used with good results. About 30 gallons of oil should effectively soak 10 bushels of sawdust - the latter should be dry and fine and from well seasoned wood. It should be soaked in oil for at least 24 hours and the particles should separate completely on broadcasting. Tarbett(41) in Arkansas found that about 10 bushels were necessary to broadcast an acre of breeding area, but in our experience about 1/3 less than this will give moderately efficient control.

For ditches filled with seepage water and for small pools a mop on a long handle is useful for applying oil - the mop should be dipped into a pailful of oil and swished to and fro in the water. In some of these places it may be found convenient to use oil-soaked cotton waste held down by stones - the oil gradually liberated over a considerable period will give a continuous film. In large sloughs and lagoons, small sacks containing oil-soaked sawdust and cotton waste may be anchored by stones at the end of long ropes. Automatic drip barrels and drip cans have been used extensively in the past in some mosquito control projects, but careful tests and comparisons have indicated that they are not as efficient as spray pumps or other methods of hand oiling and in most mosquito projects they have been discarded and are very little used.

Cost of Oiling: This varies so much with different conditions that it is hard to give data that may be of very much value. However, in 1921 an attempt was made to ascertain something of the cost of oiling under Fraser Valley conditions. An area of 25 acres of flood water was selected for the test - five acres were dense cottonwood swamp, fifteen acres were open meadow and five acres were cultivated fields. This latter area was oiled by means of seventeen small drip cans. The five acres cottonwood swamp and fifteen acres meadow were treated by means of broadcasted oil-soaked sawdust. A survey five days later showed a ~~killing~~ mortality of about 90 %. In the open areas excellent control had been obtained, but the control in the cottonwood area was not so satisfactory owing to the difficulties of oiling in the dense vegetation. Oil used amounted to 110 gallons (20 gallons crude oil, remainder kerosene) costing $25.80. Labour amounted to five days at a cost of $30.00. The cost per acre was thus approximately $2.25. More satisfactory work could probably have been accomplished had the cottonwood swamp been divided into sections by means of cross trails, or paths. In fact it is almost impossible to carry on efficient oiling unless some trails are cut in these areas. These trails need only be very roughly cut and should run north and south, and east and west at intervals so as to divide the area into workable blocks. The trails act as a guide and render systematic oiling possible.

C. Protection from Bites of Mosquitoes:

Screening: In a mosquito ridden district screening is absolutely necessary for the comfort of the household. Wherever it is in any way possible, horse stables and cattle barns should be provided with screens as well as dwelling houses.

Effective screening for mosquitoes can only be realized when a netting is used with a mesh of at least 16 and preferably 20, strands to the inch. In the Fraser Valley the dominant mosquito is a very small Aedes and the screening is noticeably inefficient, as mosquitoes often can be observed making their way through the apertures. On examination it was found that nearly all screens in the district were 12 mesh and that at the majority of hardware ~~sseir~~ stores nothing but this could be obtained. It is suggestive to note that in some parts of the Southern States it is illegal to sell mosquito netting of less than 16 mesh.

Repellants: For those working out of doors or in places where screening is not feasable, either a mosquito veil or some protective liquid is usually necessary when mosquitoes are abundant. Mosquito veils to protect the face and neck are used very extensively in the Fraser Valley. They have, however, a number of objectionable features and are apt to hamper work by catching in berry bushes, etc. No repellants we have heard of are infallible but they are often found to be a great boon; and work in a bush area is at ~~times~~ times impossible without some such protection. A repellant strongly endorsed by the majority of mosquito workers in America, and one that in our experience has proved superior to any others tested, is the following mixture.

Oil of Citronella	2 Oz.
Spirits of Camphor	2 Oz.
Oil of Cedar	1 Oz.

A little of this smeared on exposed parts will keep mosquitoes away for some time; and a few drops on a cloth hung at the head of the bed will minimise mosquito annoyance at night.

The officers of the Dominion Forest Service and of the Division of Forest Entomology often find it necessary to camp in places badly infested with mosquitoes - the following mixture has been usde by them extensively and has proved very satisfactory.

Oil of Tar	3 parts.

Castor Oil (or Sweet Oil)	2 parts.
Oil of Pennyroyal.	1 part.

The following is the formula of a mixture which, while it may possibly be less effective than the above, has the advantage of being cool and pleasant on the skin and being less objectionable. As well as repelling mosquitoes it allays pain from previous bites.

Oil of Pennyroyal.	1 Oz.
Sweet Oil	6 Oz.
Ammonia	1 Oz.

Many proprietary substances are offered on the market during the mosquito season. These customarily appear under some fancy trade name and are accompanied by statements as to their infallibility in keeping off mosquitoes. Some may be of value but in our experience they have been disappointing, usually being high in price and low in efficiency.

Repellants for Protecting Cattle: A number of entomologists have devoted much attention to the development of practical repellants for protecting live stock from fly attacks. The ideal repellant should be non-toxic and should result in no ill effects when applied externally; it should have a strong repellant effect upon all flies affecting ~~cattl~~ live stock; and the repellant action should last at least a week. ~~It must~~ few substances yet developed approach perfection and Dr. Hadwen (42) states the case as follows. "Fly repellants and dressings of all sorts are advertised and sold to farmers, but though many of them will ward off ordinary biting flies for a short time, their beneficial effects last for too short a period to be of any practical Value". In the Fraser Valley a number of commercial fly sprays are used with apparently moderately good results as mosquito repellants. They are mainly used for dairy cattle and, in some cases for work horses; and we believe in this

connection that protective sprays have a place, although their practical value for live stock in general is somewhat p problematical. Of home made mixtures the following is well recommended for cattle flies in general - we have, however, not tested it specificially for mosquitoes.

Common Laundry Soap	1 lb.
Water (Soft)	4 gallons.
Crude petroleum.	1 gallon.
Powdered Napthalene	4 Ozs.

The soap should be shaved fine and dissolved in warm water, the Napthalene should be dissolved in the oil and the two solutions should then be thoroughly mixed for 15 minutes in an old dasher churn. It may readily be applied by means of a large brush and it is claimed that two applications a week are sufficient. The mixture must be always well stirred before it is applied.

Some observations and experiments made by Dr.C.P. Coogle [43] in Mississippi, suggests to one that Creosote oil might be used effectively to keep cattle barns, horse stables, etc., free from mosquitoes even in the most severely affected places. In the above experiments Creosote oil applied to walls and ceilings in certain negro quarters had a strong repellant effect upon Anopheline mosquitoes for a period exceeding 10 weeks. The quantity used was one gallon per 420 square feet. Prior to the application of Creosote oil, inspections showed the houses to contain very large numbers of Anopholes - in one case 103 in one small house. Two inspections following creosoting failed to reveal a single mosquito of any sort in any of the 25 houses.

In the Fraser Valley one application of Creosote oil should keep cow sheds, stables, etc. free from mosquitoes during the entire mosquito season at a very moderate cost. We believe that creosoting the inside of rough buildings will have a very wide application in keeping live stock in good

condition during mosquito outbreaks. Hadwen (44) indicates the value of rough shelters in meadows and range areas. If such shelters were creosoted perfect protection would be obtained from mosquitoes and probably all other biting flies.

The entrance to such sheds, cattle barns, horse stables, etc. should have a ~~bit~~ piece of creosoted sacking or burlap stretched over the upper portion of the entrance, as the majority of the mosquitoes and other flies will, then be brushed off when the animal enters the shelter.

Smudges and Fumigants: It is unnecessary to enlarge on smoke smudges made by burning damp vegetation, as almost everyone in the affected district has had experience with them. A dense smoke of any sort will help to keep mosquitoes away. Inside houses fresh pyrethrum powders provide perhaps the most satisfactory means of clearing mosquitoes from rooms. The powder, burned slowly, gives a pungent smoke that will stupify mosquitoes and cause them to drop to the floor. Windows and doors should be closed while the powder is burning. A convenient way to burn the powder is to make a little pyramid of it in a tin and light the tip; or the powder may be moistened and formed into small cones - these will burn well when dry. To actually clear buildings of all mosquitoes requires 1 lb. of powder per 1,000 cubic feet of space but a much smaller quantity will usually give relief from biting. Some other substances that have been recommended as fumigants or deterrents for mosquitoes are Sulphur, Powdered Gimson Weed (Datura stramoniam) plus 1/3 Niter ; Dried Orange Peel, Nimms culicide made of equal parts of carbolic acid crystals and gum camphor. cresyl and cresol. The last three need to be carefully volatalized but the others merely require burning.

In rough shacks creosoting walls and ceilings as mentioned above will give perfect protection over a very long period.

Remedies for Mosquito Bites:

Few substances appear completely satisfactory for allaying the pain of mosquito bites where severe biting has occurred; and as the poisons of different mosquitoes vary greatly in intensity and effect upon different individuals it is possible that what gives the greatest relief to one individual may not do so in another. Dr. Howard recommends moistened toilet soap rubbed over the bite, Peroxide, weak ammonia, alcohol, glycerine, and iodine have all been well recommended and any of these will do much to minimize the pain of irritation. Moth balls (Napthalene) rubbed on the bites are said to be very efficacious.

D. Conclusions and Recommendations:

In a memorandum (7) on the Fraser Valley mosquito pest submitted in 1918 to the Minister of Agriculture at Victoria; by Messrs. A.E. Cameron and R.C. Treherne of the Dominion Entomological Branch and Seymour Hadwen, Pathologist, Health of Animals Branch, is the following paragraph:

> "Until a complete survey of the mosquito breeding areas in the Fraser Valley has been made, no definite and accurate advice strictly applicable to local conditions can be advanced. Moreover it is essential that the life-histories of the different species of mosquitoes should be closely studied with a view to acquiring more exact information of the habits of each one".

These data have now been collected; although not completely, at least in considerable detail, and are presented in the foregoing pages. We are now therefore in a fairly good position to size up the mosquito situation in the Fraser Valley. Two species breeding in the flooded bottom lands are responsible for the pest - one occurring mainly in the Cottonwood flood swamps and the other in open meadow areas.

Larvae hatch almost immediately upon flooding and development to the adult may be within as short a period as twelve days or may be prolonged for nearly a month - any oiling done should therefore be carried out as soon as possible after height of flood. Sufficient flooding to cause a really serious pest does not occur until the river level exceeds 18½ feet, but other factore than flooding are sometimes involved as occasionally no pest materializes even though an exceptionally high flood has occurred. Dyking and pumping, by eliminating the breeding areas; obviously offer the most satisfactory and permanent solution for the trouble, and we do not feel that other temporary control measures would be feasable for those areas where large acreages are involved. Reclamation of flood areas should therefore be strongly supported by all those anxious to see the mosquito pest reduced. Reclamation and clearing have already resulted in a very great reduction in mosquito numbers, as all evidence points to the fact that the pest ~~xxkxxpxxst~~ in the worst season of recent years does not compare in intensity with the hordes of mosquitoes that infested the valley during the time of early settlers. As further land reclamation is accomplished the mosquitoes will proportionately decrease. Oiling is a very poor substitute for reclamation but could, we beleive, be fairly successfully undertaken in the smaller flood areas. To facilitate systematic oiling in dense cottonwood flood swamps some brushing may be necessary, and cross-trails dividing the areas into workable blocks would appear to be essential. The control of the Fraser Valley mosquito pest should be considered as a matter to be dealt with co-operatively by the various minicipalities and other governing bodies concerned. This is necessary owing to the migratory habits of the two dominant mosquitoes.

If two adjoining municipalities did not co-operate the effect of efficient work accomplished in one vicinity might be nullified by mosquitoes flying in from a nearby municipality where no control work was attempted. This should not be taken to imply that mosquitoes breeding in Nicomen Island, for instance, would have any effect so far West as New Westminster, but extensive migrations of ten to fifteen miles appear quite possible, and this should always be kept in mind when control work is attempted. If the various municipalities would co-operate and invest their authority in a central mosquito control board, we believe that much could be done to mitigate the nuisance.

The writer, in concluding, wishes to make acknowledgements of assistance received ~~of~~ from Messrs. Crawford and Randolf who were attached to his laboratory in 1920 and 1921 respectively. And also desires to express his appreciation of the valuable help and kindly interest of Dr. H.G. Dyar, of the United States National Museum. My thanks are also due to Mr. Arthur Gibson, Dominion Entomologist, for permission to utilize these data for the purposes of a thesis and for much encouragement. Mr. Eastham, Plant Pathologist for British Columbia, kindly brought to my attention Lord's notes on mosquito conditions in the Fraser Valley in 1860.

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